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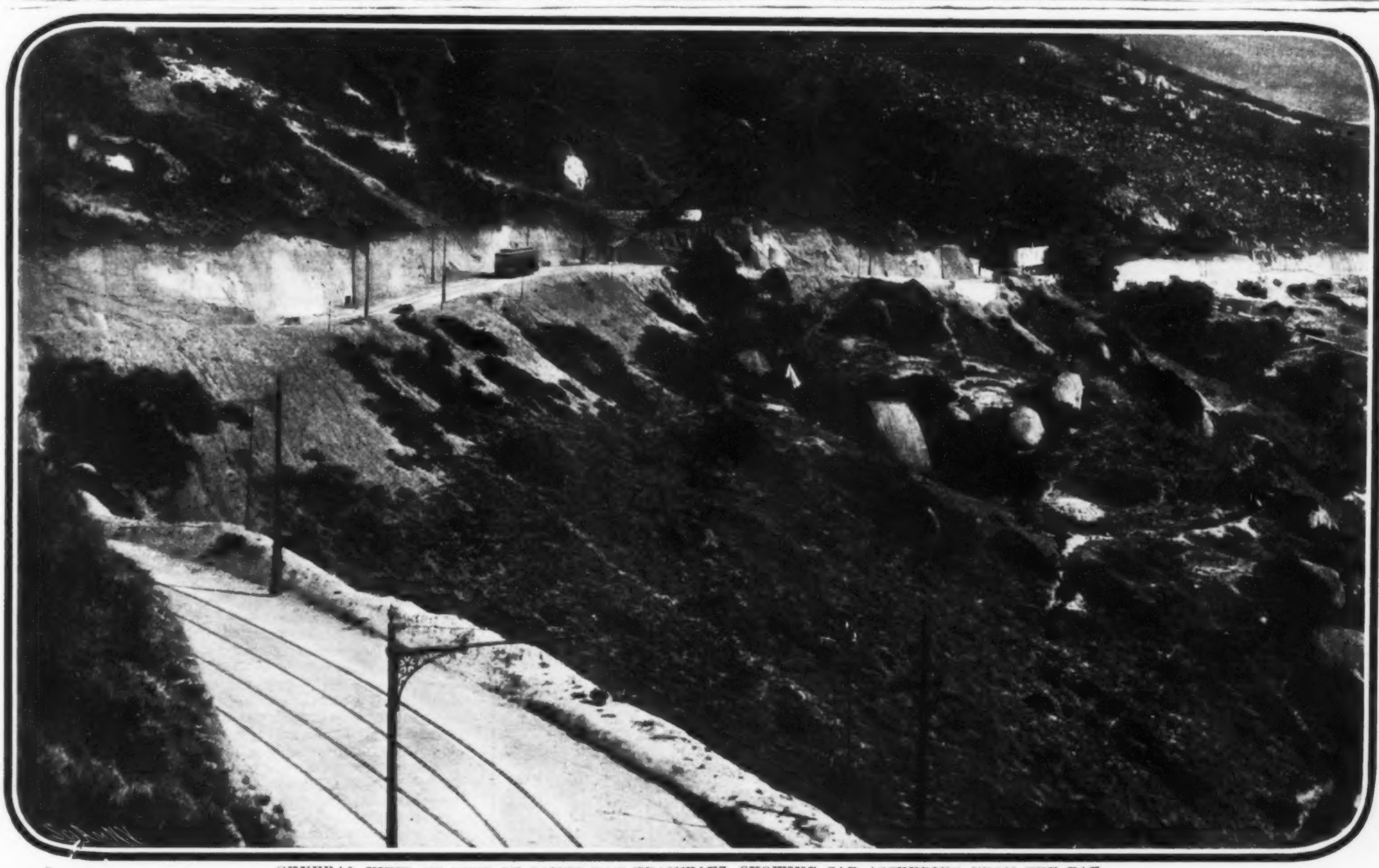
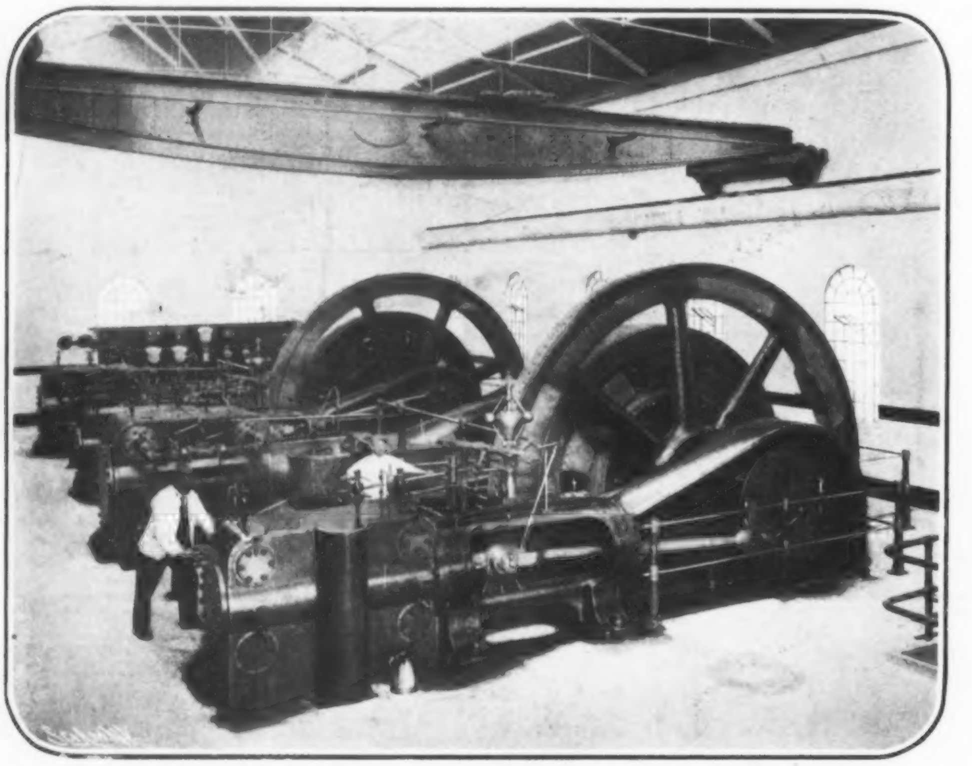


GENERAL VIEW ON LINE OF CAMPS BAY TRAMWAYS, SHOWING CAR ASCENDING FROM THE BAY.

The Tramway skirts the Bay and ascends along a Road for the most part cut out of the Rock.

THE HIGHLANDS SURROUNDING CAMPS BAY, AT THE HEAD OF WHICH STANDS THE POWER STATION OF CAMPS BAY TRAMWAYS.

ELECTRIC TRACTION AT CAPE TOWN.



INTERIOR OF ENGINE ROOM—CAMPS BAY TRAMWAYS.

ELECTRIC TRACTION AT THE CAPE.

Among the important British colonial tramway systems, that of the Camps Bay and Cape Town ranks high. This system, as it exists to-day, is a natural extension of the previously existing Cape Town line, although the Camps Bay section is owned by a separate financial organization. The construction of this tramway would have presented numerous difficulties under ordinary circumstances, but it will be admitted that these were considerably enhanced when it is remembered that the whole of the work was carried out during the progress of the Boer war. Not only did the course of the war prevent easy shipping facilities, but serious trouble arose from the difficulty of obtaining adequate labor. Yet, in spite of these drawbacks the tramway system, comprising nine miles of difficult track work, has been completed without any serious delay. The whole of the materials for the system, and a good deal of the supervision necessary in erection, were supplied and carried out by Messrs. Dick, Kerr & Co., Ltd., whose experience in the construction of foreign tramways has been unique as far as an English company is concerned.

Beginning at the Round Church, Sea Point, on the southwest of Cape Town, where connection is made with Cape Tramway, the line commences on an easy ascent, which, though gradual, causes it to reach at the end of the first mile an altitude of nearly 300 feet, and to encounter grades of 1 in 12 or 8.33 per cent. Continuing southward, Upper Clifton is reached, and at this point a magnificent view is obtained of Camps Bay and the range of mountains, to wit, the Twelve Apostles, stand out clear and distinct.

Continuing in a scarcely perceptible descent, the line passes the Old Toll House, and at Camps Bay the track leaves the roadway and continues its course over land purchased by the company. Some three-quarters of a mile distant stands the power house.

After passing the power house the tramway leaves the existing roadway, and is laid over the private estate of a local land company. Following a new roadway which has recently been made for the purpose, the most southerly point of the tramway is reached at Oudekraal. Here the line diverges in a northeasterly direction, and, after encountering the heaviest grades of the system, the highest altitude is reached at Kloof Nek. At this point, some 800 feet above sea level, there is obtained one of the finest views in the Colony. To the south the rugged scenery of Camps Bay and Oudekraal, to the north Cape Town and its world-famed Table Bay, while dimly in the distance lie the Blue Berg Mountains, the Lion's Head and Table Mountain being on either hand. As affording some indication of the difficulties of construction, it may be observed that the average grade from Kloof Nek to the terminus at Burnside Road, a distance of little more than 1¼ miles, is slightly steeper than 1 in 12. Severe though this may be, it is exceeded in other places, where grades of 1 in 9 are encountered for short distances.

The distance from the Round Church at Sea Point is, roughly, 7 miles.

From the foregoing description it is clear that the laying of the permanent way involved more than the usual difficulties. It called for not only a considerable length of new roadway, but more than 75 per cent of the existing roads had to be widened and graded. Though blasting operations on a large scale were necessary, they provided the compensating advantages of much excellent stone for concrete and road metaling. Moreover, the decomposed granite proved a suitable material for surfacing the roadway.

Besides making provision for carrying off the heavy rains by means of capacious drains and culverts, massive retaining walls had to be constructed, consisting of dry stonework laid in courses. In places these were of exceptional strength, measuring from 6 to 10 feet thick at the base, and from 20 to 25 feet in height, crossing the deep sluits or water-courses on the estate.

The gage of the tramway is 4 feet, 8½ inches; and is thus uniform with the Cape Town tramways, over which system running powers have been obtained. The rails are of girder sections, weighing 90 pounds to the yard. They are laid on a concrete foundation, a strip of concrete 6 inches deep and 18 inches wide, composed of 5 to 1 Portland cement, being laid under each rail. Karri wood paving has been laid for a width of 1 foot, 10 inches, on each side of the track, and a 9-inch toothing course along the inner side of each rail. The rail joints are each bonded with two 6-0 S.W.G. "Neptune" rail bonds. Special cast steel points 8 feet, 8 inches long, and 1 in 9 crossings have been used.

The side-wire system has been adopted, the trolley wire (No. "O" B.W.G.) being carried at a height of 18 feet, 6 inches, above the rail level. The poles are of mild steel, tapering from 7 inches at the base to 3½ inches at the top, and are furnished with ornamental base castings, finials, and brackets. The arms vary in length from 6 feet, 6 inches, to 15 feet, according to the width of the road, the average distance of the farthest trolley wire from the center of the track being 10 feet. Owing to the tortuous character of the route, it has been found necessary to run the trolley wire partly on one side of the road and partly on the other, to allow of the poles being fixed in the most suitable positions. As many of the curves are of very sharp radii, it will readily be understood that the wiring of these required considerable care to avoid the use of a large number of poles and the angles of the trolley wire being too acute. As can be seen from the description, it is probably one of the most tortuous and heavily-graded systems equipped on the overhead system.

The generating station and car shed is situated at Camps Bay, almost at the southern extremity of the system. This site was the most suitable owing to its proximity to the sea, from which water is drawn for condensing purposes. Another reason lay in the fact that a continuous supply of fresh water for boiler feed purposes is obtainable from a spring, a small stream flowing therefrom down Table Mountain.

The position is fairly central, being near the apex of a triangle formed by the two branches of the route.

The engine room is 94 feet by 42 feet, and consists of two floors and a condenser pit. An overhead traveling crane, arranged for hand power and capable of lifting 10 tons, runs the whole length of the engine room, and has a lift of 16 feet. The boiler house is 94 feet long by 43 feet, 5 inches wide.

The car shed, which is also part of the same buildings, is 136 feet long by 94 feet wide, with 8 lines of track, 4 of which have pits running their entire length.

At the entrance to the car shed are offices, mess-room, and stores.

The generating plant consists of two direct-coupled 400 kilowatt sets. The engines, constructed by Messrs. Yates & Thom, are of the cross compound type, developing 720 brake horse power with a steam pressure of 150 pounds in the cylinders, when running at 90 revolutions per minute. The main shafts are 19 inches in diameter, and on these the generators and flywheels are keyed. The latter are 18 feet in diameter, and weigh about 24 tons. The cylinders are fitted with Corliss automatic valve gear.

The generators were built at the works of the English Electric Manufacturing Company, Ltd., Preston, and were subjected to severe tests by the engineers of the company, Messrs. Alfred Dickinson & Co., Birmingham, who were highly satisfied with the way in which their specification had been met. The output of the machines is 400 kilowatts at 550 volts. They are compound wound and are in accordance with the standard practice adopted at Preston, and similar to those which Messrs. Dick, Kerr & Co., have supplied to many tramway and lighting authorities in the United Kingdom. The chief features of these generators comprise the use of a high-permeability cast-iron magnet frame, into which are cast laminated steel pole-pieces. The armature is built up on a special form of spider, in which the sections of the rim are unconnected, thus avoiding shrinkage strains. The core is built up of steel laminations, spacing laminations being inserted to form ventilating ducts for cooling the interior of the core and the windings. The armature coils are laid in open slots on the periphery and are interchangeable. The commutator is carried on its own ring, which is mounted on an extended limb of the armature spider. The commutator bars are of hard-drawn copper, and are firmly clamped by means of steel end rings. Equalizing rings are attached to the commutator and equalize any slight variations in the magnetic reluctance of the various magnetic circuits, thus checking the slightest tendency to spark.

The switchboard consists of nine panels of which three are generator panels, three feeder panels, one station panel, one lighting panel, and one leakage panel. Two of the generator panels only are in use, the other being a spare panel. Each is fitted with a positive and negative quick-breaking switch capable of carrying 1,000 ampères, a magnetic circuit breaker, and an ammeter reading from zero to 1,200 ampères. Two of the feeder panels are in use, the other being a spare. Each is fitted with an automatic circuit of the same type as those used on the generator panels, an ammeter reading up to 500 ampères, and a quick-break switch for connecting feeder to bus bar.

The main station panel is fitted with a main ammeter reading up to 3,000 ampères, on which the total output of the station is constantly shown, and a recording wattmeter. It is also fitted with a recording voltmeter with a working pressure of 550 volts.

The leakage panel contains all the instruments necessary for testing for leakage, etc.

The lighting panel is arranged for six 50-ampère double-pole circuit switches with fuses and throw-over switches.

In the condenser pit are two surface condensers with combined air and circulating pumps. These are of the Admiralty type, and are specially devised for using sea water. The sea water is supplied to the condensers by means of large cast-iron pipes, which are carried well out beyond low-water mark. To avoid the danger of seaweed being drawn up into the condensers, the suction pipe has been intercepted on the shore by a sump built in concrete carried well down below low water level, which is easily kept clear.

In the boiler house are two water-tube boilers, each with a heating surface of 3,654 square feet and capable of evaporating 12,000 pounds of water per hour under normal conditions. Each boiler is fitted with a dead-weight safety valve and a spring valve set to blow off at 160 pounds pressure. The collars are fed by means of two compound non-condensing duplex feed pumps working at a pressure of 160 pounds, and capable of delivering 24,000 pounds of water per hour against a boiler pressure of 160 pounds. Before being pumped into the boilers the feed water is passed through a fuel economizer containing 288 pipes fixed in the main flue. The chimney stack is 125 feet in height and 5 feet inside diameter at the top.

The works are equipped with the necessary machine tools for the purpose of carrying out the repairs, and comprise a large screw-cutting gap lathe, wheel lathe, wheel press, drilling machines, grindstone, smith's hearth and fan, the whole being driven by an electric motor.

The feeders are lead covered and insulated with paper and vulcanized rubber. They are laid in cast-iron troughs 18 inches below the surface and surrounded with bitumen. The main cables are laid in half-mile sections, and at the junction of each section a feeder pillar is placed in which the cables are connected to a bus bar and from thence to the trolley wires in the usual manner.

It is natural that climatic conditions should, to a great extent, determine the type of cars, and a variety has been necessary in the case of Cape Town. The cars are single-deck bogie type; part are what are known as gridiron open cars and part are of the combined type. The former have a seating capacity of sixty-five pasengers, and the latter of fifty-four. The length of the car is 40 feet, width, 7 feet, 6 inches, and height inside 8 feet. They were built for Messrs. Dick, Kerr & Co., Ltd., by the Electric Tramway Carriage Works, Preston, and shipped to Cape Town completely finished, the only work to be done before they could commence to run being to mount them on the trucks, connect the wiring, and fix the trolley poles. In passing it may be observed that, so popular has Camps Bay already become, that the company anticipate that the present equipment of cars will shortly be found too few to cope with the traffic. The car bodies are mounted on trucks of the bogie type, each truck carrying two motors, one on each side.

Departing somewhat from the usual lines, the equipment of the cars comprises four motors each, of 25 brake horse power, so that each car is capable of developing 100 brake horse power. There is hardly any question that four motor equipments with long cars are imperative where grades are heavy, and in the case of Camps Bay the gradients are unusually severe. Not only, however, is a proper distribution of power necessary, but the question of braking and retardation is of prime importance. The brakes therefore, on these cars have received very careful consideration, three brakes having been fitted, viz.: a hand brake with a brake block on each of the eight bogie wheels, an air brake acting in conjunction with the hand brake, and an auxiliary slipper brake. In addition to these it is also possible, by throwing over the reversing switch, to convert the motors into generators, thus enabling them to act as a powerful

emergency brake. The cars are operated from either end, by means of a special controller designed for four-motor equipments.

CONTEMPORARY ELECTRICAL SCIENCE.*

ELECTRIC POTENTIAL AND SURFACE TENSION.—N. A. Hesehus points out a relation between electric potential and surface tension which is supported not only by experiment but also by the dimensions of the physical quantities involved. If, after Williams and Joubin, k and μ are given dimensions such that the electromagnetic quantities acquire formulæ involving integral powers of length, mass, and time, and if, further, μ is taken to be a density and k the reciprocal of an elasticity, the quantity of electricity acquires the dimensions of a surface, and the E. M. F. acquires the dimensions of a surface tension. The author points out that this is open to a direct physical interpretation, and refers to his own experiments on frictional electricity. A surface tension is an energy per unit of surface. Two different bodies, such as ground glass and smooth glass, have different energies per unit surface; and when these energies are given an opportunity of equalizing as by rubbing the surfaces together the difference of energy will appear as a difference of potential. On the same dimensional system the intensity of the electric field appears as a pressure or energy per unit volume, and the magnetic field as a linear velocity. The electric quantities, generally speaking, involve T^{-2}, or an acceleration, and the magnetic quantities involve T^{-1}, or a velocity.—N. A. Hesehus, Physikal. Zeitschr., September 15, 1902.

IONIZATION OF AIR BY PASSAGE THROUGH WATER.—In continuation of his recent experiments, J. J. Thomson has further studied the effect produced on the conductivity of air by bubbling it through water. The air from a large gas holder of about 350 liters capacity was bubbled vigorously through water by making the air in the vessel circulate through a water pump; this treatment increased the conductivity of the air, and when the bubbling had been going on for some time, the conductivity of the air was 10 or 12 times the initial conductivity. When once the air has been put in this highly conducting state, it stays in it for a very considerable time; a large part of the conductivity produced by the bubbling remains in the air 48 hours after the bubbling has ceased; nor does it disappear when an intense electric force is kept applied to the gas. The effect produced by the passage of the air through water is similar to that which would be produced if the bubbling imparted a radio-active "emanation" similar in properties to those emitted by thorium and radium. The conducting gas can be passed from one vessel to another; it retains its conductivity after passing through a porous plug; passage through a long tube heated to redness destroys the conductivity; it takes, however, a very high temperature to do this. Temperatures less than 300 deg. C. or 400 deg. C. seem to produce comparatively little effect; if the gas is passed very slowly through a long tube filled with beads moistened with sulphuric acid, the conductivity is destroyed. Unless, however, the stream of gas is very slow, the air retains a good part of its conductivity in spite of the sulphuric acid. Another point of resemblance between the "emanation" from radio-active substances and a gas in this state is that if a strongly negatively electrified conductor be kept in the gas for some time, the conductor becomes radio-active; this activity was only reduced by about 20 per cent., when the conductor was washed in water and then heated in the flame of a Bunsen burner. The radio-activity reduced in this way disappears in the course of a few hours.—J. J. Thomson, Proc. Cambridge Phil. Soc., Easter, 1902.

RADIUM BROMIDE.—F. Giesel gives some interesting particulars concerning the properties of radium bromide, which he has obtained in a pure state of fractional crystallization of the barium and radium bromides, and which is manufactured at the Braunschweig quinine works. Experimenting with 0.5 gramme, the author found that the salt showed a rich bluish phosphorescence, especially in the dry state. The spectrum of the phosphorescence is continuous. The effect upon the fluorescent screen and the photographic plate may be compared with that of a small Röntgen tube. As the purification of the bromide proceeds, the green barium spectrum in the Bunsen flame vanishes, and the flame becomes crimson. The flame spectrum of radium consists of two bright bands in the red, an intense line in the blue, and two indistinct lines in the violet. Of the two bands, the one nearest the yellow is the brighter, and is sharp and homogeneous, whereas the other consists of a dark separation line, a bright line, and several series. The bright blue line is probably the same as that found by Demarçay at λ 4,826.3 in the spark spectrum. Radium belongs to the elements which are easily detected by the spectroscope. A fair quantity of barium is quite obscured by a small quantity of radium, especially in the red. That Demarçay did not notice the red bands is probably due to a difference in the two spectra.—F. Giesel, Physikal. Zeitschr., September 15, 1902.

LUMINESCENCE OF WIRES IN A VACUUM.—J. Borgmann has extended his researches on luminous lenses round wires in a vacuum to the case of two wires, mounted parallel to the axis of a tube 75 cm. long, and connected with an induction coil. A narrow strip of tinfoil was stuck along the tube outside. The author describes the various phenomena produced by connecting one or both of the wires with the induction coil and exhausting to various degrees of vacuum. When the pressure is 4 mm. to 6 mm., and both wires are joined to the positive pole, with a spark-gap in parallel with the pole of the coil, and the strip of tinfoil not earthed, both wires show portions of luminous lenses at right angles to the axis of the tube. These lenses are motionless as long as the interrupter works uniformly, and occur at nearly equal intervals along the wires, but displaced in one wire with respect to the other. The space between the wires remains dark. When both wires are connected to the negative pole, and the tinfoil is earthed, two luminous surfaces appear between the tinfoil and each wire. When the pressure is a fraction of a millimeter, then the lenses observed in the first case are changed into cylindrical sheaths of violet light surrounding the wires, and in the second case there are longitudinal sheaths of light interrupted by dark rings. There is also the shadow of each wire thrown by light from the other.—J. Borgmann, Physikal. Zeitschrift.

* Compiled by E. E. Fournier d'Albe in the Electrician.

ELECTRICITY IN MODERN RAILMAKING.

THE introduction of electricity in railmaking and the substitution of the electric motor for the steam engine in this work are of quite recent date, but they may be said to have truly revolutionized the steel-making industry. The numerous and varied purposes to which electricity is put in modern steel works are well illustrated in an article which is contributed by Mr. J. Hays Smith to the Engineering Magazine. The author takes as a typical example of this development the case of the Edgar Thomson Steel Works, near Pittsburg, in the United States, which is the largest railmaking establishment in the world. The output of these works the past five years has increased enormously, the enlarged production having been made possible by adopting electricity to operate the various metal saws, roll tables, cranes, rail conveyors, and machine tools. But to obtain a clear understanding of the part that electricity plays in the process of railmaking, the onward movement of the raw material, the metal, and, finally, the rail itself must be followed. The point of starting is the ore yard, and up the side of the blast furnace, by an almost vertical incline, pass swiftly-moving cars carrying the ore, coke, and limestone in the exact proportions requisite for the production of iron. Electric motors hoist and dump the contents of these cars into the furnace top. The tanks containing the liquid metal are also tilted by an electric motor and their contents poured into other metal cars standing below. These cars, which are electrically operated, discharge into the mouth of the converter, which has been turned down to receive the white-hot metal, again by the aid of an electric motor. The preparation for the rolling process is almost as important as the rolling itself. Therefore, before rolling, the unevenly-cooled ingot is brought to a uniform temperature, which is accomplished in reheating furnaces. Above the bank of these furnaces are four monster electric tongs always busy in lowering or raising ingots. The tongs are suspended from a derrick-like car that travels back and forward on the bridge of an electric crane, which runs above the entire line of furnaces. Not only is the ingot hoisted electrically from the soaking pits, but also electrically conveyed to the blooming mill about 100 feet away. After a number of passes over the blooming rolls, the metal becomes a bloom about 15 feet long and 9 inches square. The next process is to cut the long bloom up into smaller blooms, in which electrically-driven bloom shears are brought into play. The rough ends—"crop heads"—are cut off and are placed by an electric crane in a car for shipment to any part of the works. Formerly eight to ten men were employed in wheeling the crop heads out from the bottom of the chute; now a boy and a helper dispose of them. Before the sheared bloom is finally rolled into rails, it is again placed in a reheating furnace. From this furnace it is drawn on the opposite side by an electric "drawer" and deposited on a buggy. It is then carried to the rail mill, where the transfer to the rolls is effected by a line of electrically-driven rollers. Here begins the final process of making the rail. Everything except the heavy rolls that shape the steel is electrically operated. The red-hot steel passes into the rolls, and, rushed back and forward on electrically-driven rollers, it lengthens with each pass, until finally it runs out a thick bar about 30 feet long, when a set of transfer arms picks it up and throws it bodily to a second set of rolls. The steel bar quickly reaches a length of 100 feet under this process, and a third set of rolls finishes it off into its final and familiar T form. The long rail then passes to the hot saws, which, electrically driven, cut the rail in three pieces, each 30 feet long. Lastly, a motor-driven rail conveyor carries the finished rails out to the shipping skids, and they are ready for the market. The most remarkable feature of the manufacture of these rails is that from the beginning to the end man has not touched the metal, owing almost entirely to the extensive part played by electricity in the process.—The Electrical Engineer.

TELEPHONES IN ENGINE CABS.

COMMENTING on the recent New Jersey Central disaster, an official of the Baltimore & Ohio Railroad told the Baltimore American in an interview something of a new safety device for railroads which has been tested in Germany.

The device is the joint invention of Messrs. Hubert Pfirmann and Max Wendorf. Midway between the rails is laid a light third rail of the ordinary T pattern, the joints of which are so connected as to form a continuous conductor. With this initial statement the nature and operation of the device are described as follows:

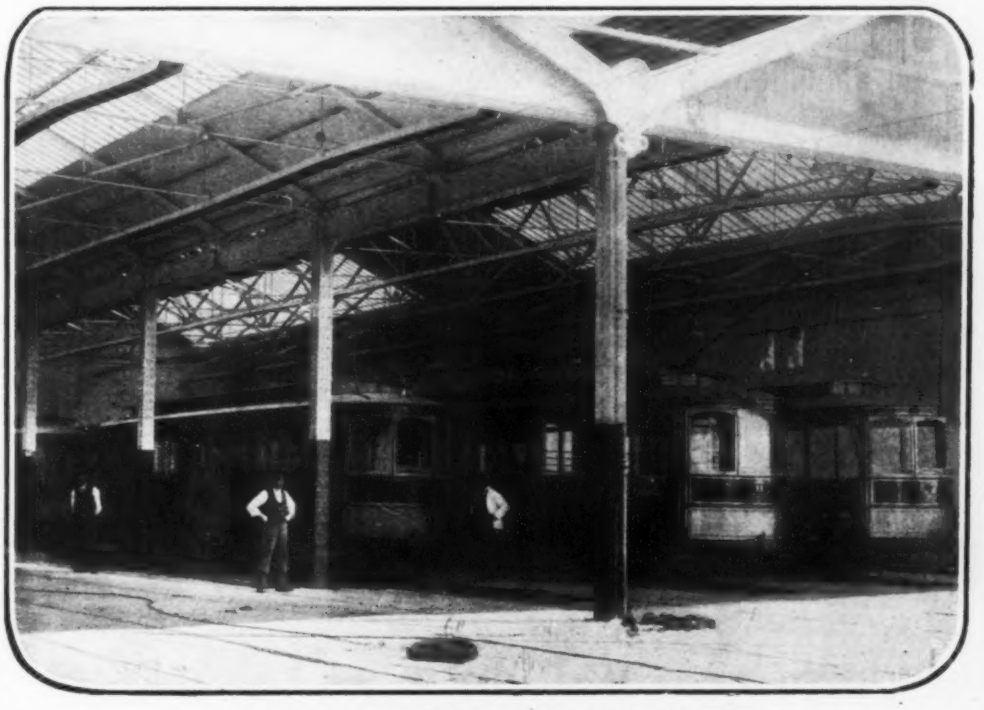
Midway under the forward part of the engine is hung the working instrument, an electrical apparatus inclosed in a square case or jacket occupying a cubic foot of space. The instrument is connected with a contact shoe, which slides along the third rail, and by wires with a telephone and electric alarm bell in the cab of the engine and a red incandescent lamp, which is lighted by the same impulse that rouses the alarm bell into action. A further improvement of the device sets the electric brakes on the engine or entire train simultaneously with the alarm signal which sounds the bell and lights the lamp. The apparatus is so adjusted and arranged that the engineer can at any moment, by touching a lever, satisfy himself that it is in full working condition.

The tests recently were conducted on the main line from Frankfort to Hanau, between the stations Sachsenhausen and Goldstein, and a translation of the official report will illustrate concisely the working of the apparatus. Two locomotives, numbered respectively, 290 and 1420, had been equipped with the new device and the experiments proceeded as follows: Engine 290, drawing a special train and approaching Sachsenhausen at full speed, received the danger signal and came to a full stop; the engineer of 290 then asked by telephone the cause of the signal and received from the keeper of a grade crossing half a mile in front, word that a wagon had broken down in crossing the track and obstructed the line. After ten minutes' wait, the engineer of 290 received word by telephone that the obstruction had been cleared away and thereupon resumed his trip.

A mile further on, the signal on 290 again sounded, and the engineer was informed, by telephone as before, that the semaphore round a curve and more than half a mile distant was set at "halt." Thereupon engine 290 slowed down and proceeded cautiously, sounding its whistle at short intervals, the telephone bell in the cab ringing continuously until the curve was rounded, when the ringing ceased, notifying the engineer that the semaphore had changed to "track clear." Thereupon 290 resumed full speed.

In the tests to prevent collision, engine 1420 came up rapidly from behind and on the same track as 290, which had slowed down and was proceeding cautiously, in consequence of reported danger in front. The moment that 1420 came within 1,000 meters (1,093 yards) of 290, the signals on both engines began to ring and their red lights to glow. Thereupon 1420 halted, the engineer inquired of 290 in front the cause of the alarm, and a complete understanding between the two trains was immediately established.

An important point in this connection is that in practice the same warning signal is sounded upon every engine equipped with the apparatus, which is on the same track, and within the prescribed radius—a kilometer or a mile, as the case may be—from the engine and train which cause the obstruction. If a semaphore be falsely set at safety, the train may run past it into a block in which another engine is halted



INTERIOR OF CAR SHED—CAMPS BAY TRAMWAYS.

or moving with perfect security that warning will be given in ample time to prevent a collision under any and all conditions of darkness, fog, storm or mistaken instructions.

The invention has other minor points of usefulness, but the foregoing will be sufficient to indicate the general method of its operation and the measure of its efficiency. In effect, it puts the engineer of every train into instantaneous touch with other trains, switchmen, and station and crossing keepers in his neighborhood; and keeps ever before his eye and ear an automatic and infallible signal which springs into activity the moment that his locomotive, whether running forward or backward, comes within the radius of danger from collision.

The German government has directed that a section of track be equipped with the apparatus for careful, practical experiments, and it is reported that the government of Russia has obtained license to test it in actual service on its new military lines now under construction in Siberia.

ANTI-FRICTION BEARINGS.*

Henry R. Lordly, C. E.

Probably few subjects in engineering have more general interest than that of reducing friction and thus saving power, but if existing literature be taken as a criterion, there are few subjects which have been less generally treated upon, and fewer cases in mechanics where theory is more unsatisfactory. The reason obviously is that until quite recently no variety of anti-friction bearings, adapted for general use, has been produced, sufficient to base a comparison on; and as for the theory, there is room for more experimenting.

In addition to a knowledge of the various bearings now being manufactured, a full understanding of the problem necessitates a knowledge of all that has been devised; and the fountain head in this case is the Patent Office.

It having been within the author's province to make such researches and also to test various contrivances for reducing friction, he begs to incorporate, within the limits of this paper, such of the data obtained in an investigation lasting nearly one year, as will be of interest to the profession at large.

In order to facilitate a clear understanding of the subject this paper will review it in the following order:

(1) Classes of bearings devised.
(2) Description of one type of each class.
(3) Traction tests.
(4) Taper roller—Wright's patent.
(5) Theoretical consideration of Wright's design.
(6) Thrust bearings; turntable bearing.

In this discussion the term "ordinary bearing" is intended to mean the common style of lubricated journal now in use.

Of forty patents examined, about one-half were on the straight roller principle, the rest being divided among taper roller, ball, and ball and roller combined, designs.

For convenience in discussing, these bearings are divided into two classes:

(1) Caged bearings.
(2) Free race bearings.

A "caged bearing" is one where the roller is held by a collar or where the roller has a pin projecting into a perforated collar. In some of the early designs the weight really comes on the pin.

In the "free race," the rollers are not held by any other means than the seats between which they are confined, and each roller rotates around the inner seat as an axis. A perfect bearing must contain this feature as well as an absence of end thrust, and it will be shown in this article that there is practically but one style of bearing which conforms to these conditions.

Caged bearings include: Ball, straight roller, straight roller and ball combined, taper roller, taper roller and ball.

Free race: Taper roller, ball.

Ball Bearing.

The ordinary ball bearing is now so well known that a description is not necessary here, but the attempt to attempted. However, there are one or two which have stood testing and Fig. 1 gives the latest and probably the best design on this principle.

This is called the double ball bearing, the larger ball carrying the load, the smaller being the "idler."

F is the retaining float for *B'*, *C* the cup, and *K*, the cone. The idler, *B'*, is so placed that its center is coincident with a line connecting the centers of each of the adjacent carrier balls, *B*, which are held in place by a loose free ring, *F*, that floats with the carrier balls and is supported on the cone or shaft, but is not in contact with any of the balls when they are under load, during which time the idler balls are maintained in the same relative position by rolling contact with the carrier balls. It is thus claimed that

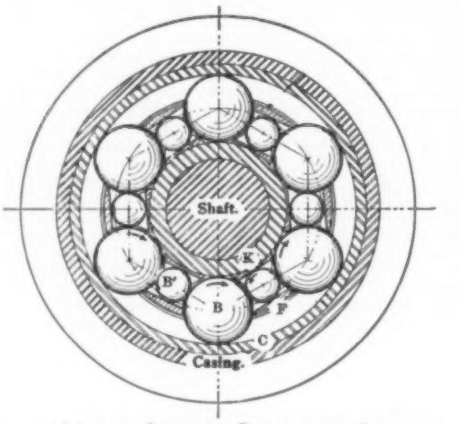


Fig. 1—Section Showing Details of Chapman Double Ball Bearing.

a positive revolution of the load-carrying balls is insured, and that with this positive revolution all cross or sliding friction is eliminated. In a car bearing it is claimed that by means of key seats and corrugated washers the automatic changing of adjustment by the jar of the car or creeping of the cone as a result of the rolling motion in the bearing is prevented. The adjustment, once made correctly, is permanent until it may become necessary to take up the wear. This wear is stated to be very slight, as has been shown in the tests conducted from time to time. This bearing has been tested on the Fitchburg Electric Railway, showing a saving of 61 per cent over the common bearing in a short run. (See Railway and Engineering Review, February 22, 1902).

For heavy work the objection to the ball bearing in general is the liability to wear both in the case of the ball and in the groove or seat.

This is explained by the fact that the ball has two motions in its race around the cone—a turning motion directly ahead, or on an axis parallel to the axle, and a side motion on an axis perpendicular to this axle.

An inventor, and a former extensive manufacturer, of ball bearings, claims that to each two revolutions ahead the ball makes one rotation sideways. Thus a point marked on a ball would trace a serpentine path. The author believes that this contention is practically correct.

Straight Roller Bearing.

This belongs to the caged class, and while more designs have been brought out on this style than nearly all others combined, there are only about two or three that have any merit. In most cases the inability to adjust for wear is the most serious drawback. In one case which the author investigated, a straight roller bearing, while showing a saving when first put on, eventually took more power to turn it than the ordinary journal. This was in heavy work.

Fig. 2 illustrates a bearing of this class which is now in actual use in many manufacturing plants and a spring roller, Fig. 3, and is known as the Hyatt flexible roller bearing.

This bearing consists, in addition to the rollers, of a steel shell, cast iron cap, malleable iron ends, cast iron saddle, and a composition guide yoke, all the parts being worked to accurate dimensions. The rollers are made of spirally coiled strips of mild steel of the highest tensile strength. Where the load to be brought upon the bearing is excessive, the shell is made of spring steel. The cast iron cap is made of high grade iron carefully ground and fitted. The malleable iron ends are grooved in a lathe, as are also the ends of the steel shell and the bead on the end piece riveted into the groove in the steel shell. Where a continuous nest of rollers is required there is used what is termed a rod yoke, composed of two rings with rods running through the inside of the rollers and riveted on the outside of the rings. This latter method of keeping the rollers in alignment gives the bearings a continuous steady line of motion, and in cases where used saves the metal from wavy lines. The cap and saddle are brought accurately to gage, so that the rollers will have a continuous, smooth, rolling motion, whether it be on the steel shell or cast iron cap. Tests made for the purpose of ascertaining what the bearing was capable of accomplishing in lessening friction showed that it produced a saving of 25 per cent of the power absorbed in transmission over a shaft running on ordinary bearings.

Combination Bearings include a number of designs employing a straight roller and a ball at ends of each roller to take the thrust; a ball and roller, the ball being between; and a number of complicated combinations of balls and rollers, most of which are more novel than useful.

As in some other cases a multiplicity of parts, inability to adjust for wear, and cost of construction destroy any great chance of commercial value.

Fig. 4 shows probably the best bearing of this style and one evidently of sufficient merit to warrant its manufacture. As an axle bearing it has evidently had some success, and the following tests made with a U. S. army wagon fitted with the device will prove interesting.

The tests were made on asphalt, Belgian block, and common dirt roadways:

Asphalt, test with common axle	100	pounds pull.
Asphalt, with roller bearing axle	25	" "
Asphalt, with common axle, starting load	450	" "
Asphalt, with roller bearing axle, starting load	220	" "
Asphalt, with 8 per cent grade, common axle	400	" "
Asphalt, with 8 per cent grade, roller bearing axle	170	" "
Belgian block, common axle	165	" "
Belgian block, roller bearing axle	75	" "
Dirt road, common axle	260	" "
Dirt road, roller bearing	100	" "
Dirt, starting, common axle	850	" "
Dirt, starting, roller bearing axle	400	" "

The "pull" means the force necessary to start the wagon.

This bearing is known as the "Standard" and is manufactured in Philadelphia.

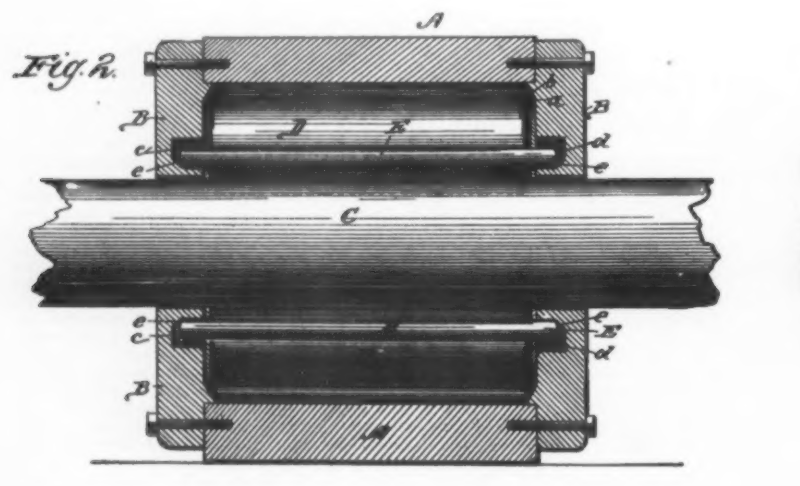
Fig. 5 illustrates a caged taper roller used principally on vehicles.

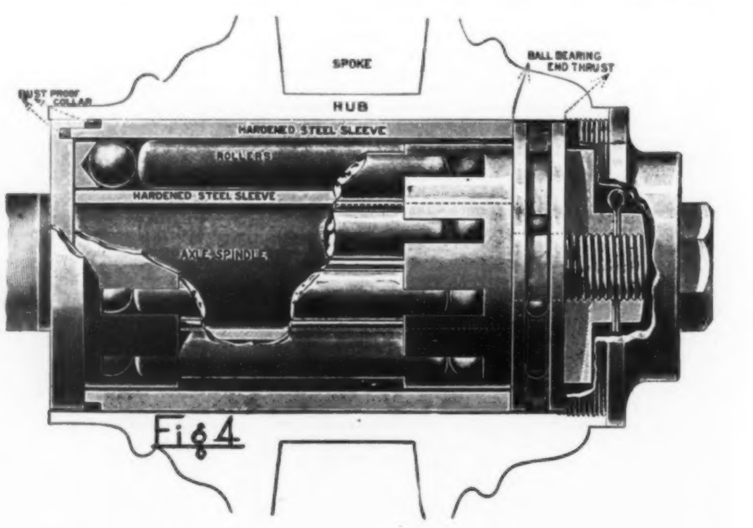
It will be noticed that the rollers have two grooves which fit over a projection or rib on the seat. These grooves are intended to keep the rollers in place laterally, and to prevent twisting or turning on the cones.

The manufacturers of this bearing claim a general saving of fifty per cent when it is used on vehicles in ordinary service. On a draft test on a level, compared, with a common axle, the saving claimed is in the proportion of 48 to 8. It took 48 pounds to start the vehicle with the ordinary axle.

At sight one would imagine that wear would be a large item against the bearing, especially in heavy work. The author has made no personal tests in this case.

We have now considered, in brief, the chief bearings under the respective heads of the classification given





use this style of bearing in the field of heavy work requires more than passing attention.

The author is in possession of various tests of large ball bearings which failed so completely as to require no further evidence of their unfitness for the work the makers state, with some reason, that it has proved all that is claimed for it. Its employment in places where the end thrust is a minimum is doubtless its strongest point. In the cut shown, *D* is the bearing roller, *E* the separating roller, *d* its bevel, and *e* the groove into which it fits. The lack of adjustment for wear is probably its weakest point.

Another style of the straight roller class contains at the beginning of this paper. Assuming that these devices are capable of doing all that is claimed in the way of reducing friction, it is evident that for general use the following objections are of moment:

1. First cost.
2. Liability to wear.
3. Multiplicity of parts.

In addition to these, it is questionable if any one of

the bearings is adapted to all the uses that a bearing can be put to.

Taper Roller.

This brings us to the most important division in our classification--taper roller, free race, uncaged bearing. Of a limited number of patents on this style there is practically but one bearing capable of being applied universally and which embodies a principle not covered by any other. This is known as Wright's design and, like a great many other clever devices, was invented by a citizen of the United States. It is not a haphazard invention, but simply the boiling down of the inventor's experience obtained while manufacturing ball bearings, of which he was practically the inventor.

The objections already stated in respect to many other styles of bearings were evidently well understood by this inventor, his experiments culminating in the design of a bearing based on a principle, proven by him, and which is stated in his claim as the "Angle of Repose."

Fig. 6 is a cut of this bearing taken from the original drawing of a journal for a street car. Fig. 7 is a photo of the parts of the bearing when made. An inspection will aid an understanding of the descriptions to come of its theory and mechanical features.

The author believes that the description given by the inventor in his patent claim, is the most concise and clearest, and Fig. 6 has been lettered correctly so that the reader may follow:

In my experiments I have discovered that if the angle formed by the line of direction of the resultant pressure exerted on the bearing with the perpendicular to either or both the treads *D* and treads *G* is greater than a certain critical angle which I have denominated a "reposing angle," then slipping of the rollers *E* will occur and a consequent end thrust will be produced. By the term "reposing angle" I mean to include not only such certain critical angles, but also all angles which are angles of less magnitude. All angles which are of greater magnitude than such critical angle or "reposing angle" I denominate as "non-reposing angles." This certain critical angle depends on the nature of the contacting surfaces and can be determined only by experiment. If the treads *D* are placed in position at a "reposing angle" and the treads *G* are also placed at such an angle, then there will occur binding and gripping of the bearing parts. If, however, the treads *D* are placed in position at a "reposing angle," then the end thrust and binding and griping of the bearing parts will be substantially eliminated.

The rollers *E* are made to fit the inner and outer treads of the roller race, so that each roller is in continuous line of contact with the inner and outer treads of its race, and it has therefore a free rolling tread over its entire length. The rollers *E* are in "full series," that is to say, the races are filled with rollers, except that sufficient space is left between them to prevent their binding or engaging in frictional contact when they are carrying the load or pressure exerted upon the bearing. They are free to rotate on their axes and to travel in the race.

For the purpose of facilitating the setting up and adjustment of the rollers, I secure to the ends of the inner treads *D*, retaining rings such as *b*, Fig. 6, and I provide the taper rollers *E* with pins, *c*, which engage freely with the retaining rings mentioned. By this means I am enabled to retain the taper rollers substantially in place for the purpose of setting up and adjusting the bearing, but this pin and retaining ring plays no part whatever in keeping the rollers in place when they carry the weight or pressure exerted upon the bearing. During such times, the pin *c* is entirely free from the retaining ring *b*. When not bearing such pressure the pin *c* and the retaining ring *b* serve only to keep the rollers *E* in their proper position in the bearing. A small space being left between the rollers *E*, the rollers will not be in frictional contact with each other when they are carrying the pressure exerted upon the bearing, since they are engaged and picked up by the pressure, one after another, from their position of contact as they fall from under the pressure to the under part of the bearing, or the part of the bearing where the pressure is not felt. In other words, space being allowed for a free action of the rollers, the pressure exerted upon them will tend to separate them and free them from any frictional contact with each other. The outer retaining ring may be formed so as to cover nearly the entire end of the roller, thus doing away with the outer retaining pin or point *d*. (This is the case in Fig. 6.)

(To be continued.)

THE HISTORY OF THE SLIDE REST.

The slide rest, which is such an important and indispensable feature of the lathe, planer, and in fact of all machine tools, was the invention of Henry Maudslay, but the logical development of the idea into the slide lathe for screw cutting and long turning, we are told, was the work of a Manchester inventor. W. H. Bailey, in an interesting historical article, "The Mechanical Inventors of Manchester," in the December issue of Cassier's Magazine, says that the invention of the slide lathe is due to Richard Roberts and that the first slide lathe is working in the shops of Beyer, Peacock & Co., at Gorton, England. The carriage of this lathe is on the front of the bed instead of being on top, as in general practice now. Roberts brought out this improvement about 1816. The front slide lathe is again coming into use to some extent in England.

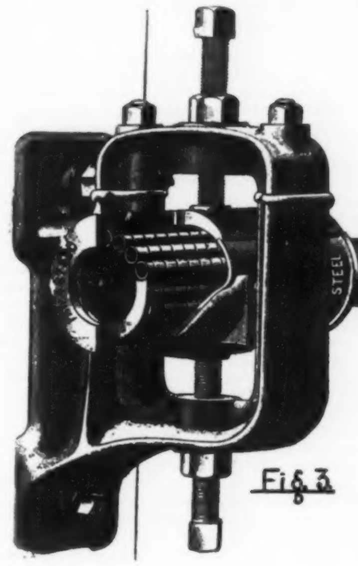


Fig. 3

Roberts also invented an iron planer, an automatic emery grinding machine, a slotting machine, an automatic drilling machine, and a punching machine that would punch holes in plates automatically to any pattern desired. The pattern was controlled by a card which was introduced into the machine and used in much the same manner as the cards in the Jacquard loom. Machines built on this plan were used for punching the plates of a number of large tubular bridges, including the Britannia, Menai, Conway, St. Lawrence, etc. The writer claims that Roberts was the inventor of the first iron planer of the type now used, but proof of this is quite impossible, since the early contemporary inventors kept their inventions secret and enjoyed the advantages accruing from the use of their machines, making exact dates unknown. It is quite certain, however, that a number of planing machines were in use at about the time that Roberts invented his.

A MECHANICAL CASHIER.

There has recently arrived in London—of course, from America—a machine which does everything except think. It is a banker, cash register, money changer, bookkeeper, and auditor. It adds up figures with lightning rapidity and absolute accuracy, and it cannot by any possibility be swindled. It requires very little attention; the only qualification for its attendant is the ability to read figures.

The machine is fed in the morning with sufficient cash to provide it with change for the day—say, £20 (that is the bank). It receives, say, a £5 note from a customer who has bought goods worth 3s. 4¾d. It pockets the money and registers the purchase (cash register). Simultaneously it picks out the change—£4 16s. 17¼d.—and places the coins all in a row—four sovereigns, one half-sovereign, two two-shilling pieces, two single shillings, a sixpence, a penny and a farthing (money changer).

While getting this change, which it does before the customer can count two, it at the same time makes a printed record of the transaction (bookkeeper), and gives the customer a receipt. While it was providing the change, it was also simultaneously adding the 3s. 4¾d. to its bank, exhibiting its total as £20 3s. 4¾d. —in other words, auditing its accounts and striking its balance. If only change is required, all that the operator has to do is to touch one key and in return for the £5 or £1 the machine at one moment provides a variety of small change.

The mechanical cashier can never go wrong, and it would baffle the ingenuity of any operator to cheat it. It will be seen that this wonderful invention just carries the operations of other cash registers one step further. It closes the one door which they leave open. It prevents the person in charge from touching any cash at all, and he will be promptly faced with a mistake if he touches the wrong key, or convicted of theft if he inserts false money—and this in presence of a witness.

When the attendant receives £1, say for a purchase, he presses down a lever to receive the money. The wheel immediately goes up one notch, and the money is secured in the bank in the £1 receptacle. This movement unlocks the keyboard and the attendant presses down the figures, say, 3s. 6d., the amount of the purchase, gives one turn of the crank, and immediately the correct change is delivered by the machine and the amount of purchase added to the total, as above described.

The one machine in London is in the meantime giving an exhibition of its capacities in a back room of 72 New Bond Street.—London Mail.

AN AUTOMATIC CALCULATING MACHINE.

The Autarith is the name of a most ingenious calculating machine recently patented by a young Viennese inventor, Mr. Rechnitzer, now of New York.

The machine is probably the first mechanism produced which is capable of performing the four fundamental arithmetical operations of addition, subtraction, multiplication, and division without any but purely mechanical assistance on the part of its operator. All the mechanical assistance needed is the motion of buttons along certain slots corresponding to the figures with which the operation is to be performed. All further movements are effected automatically through the action of a weight or spring motor, which supplies the requisite energy. In most machines for division the operator has to determine mentally the integers of a quotient, and the mechanism then gives the remainder only. But the autarith takes all mental work from the operator, giving the integers of the quotient and the rest at once. The whole process is in fact automatical when once the problem is indicated to the autarith; chances of errors are minimized, being limited to possible mistakes in stating the problem; no other errors can arise.

By means of buttons slid up and down slots the machine is "told" what to do. If, for instance, 2,647 is to be multiplied by 6,892, the buttons of one row are placed in order opposite to 2, 6, 4, 7 respectively. The second number, 6,892, is similarly recorded in another row of buttons. Lastly, a large button is shifted to a notch marked "Multiplication." The machine is immediately set into motion by the action of the motor, and presently stops, leaving the figures of the product required showing in certain spaces in proper order, and the large button returns to the "off" notch. By a precisely similar process divisions, additions, and subtractions are worked out, the only difference being that the large button is moved to the proper notch.

It is particularly interesting to watch the machine working out a division sum; it can be seen to try a quotient, and finding it too great, to correct itself and fall back upon a smaller number. The analogy with the mental calculating process is so striking that it is not surprising to hear from the inventor that he was led to the construction of the machine by considerations which were originally of a purely philosophical interest.

The machines used in some of the large offices today for multiplying and dividing are rather aids to reckoning than automatic calculators. Machines of this type were known in all essentials since the days of the great philosopher-mathematician Leibnitz, and all attempts at improving them since have not met with success. Some thirty years ago Bollée, a Frenchman, built a calculating machine upon an entirely different principle, which, notwithstanding the geni-

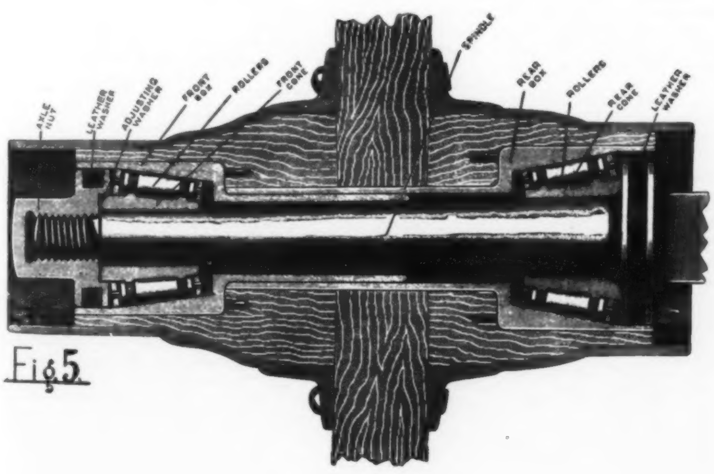


Fig. 5

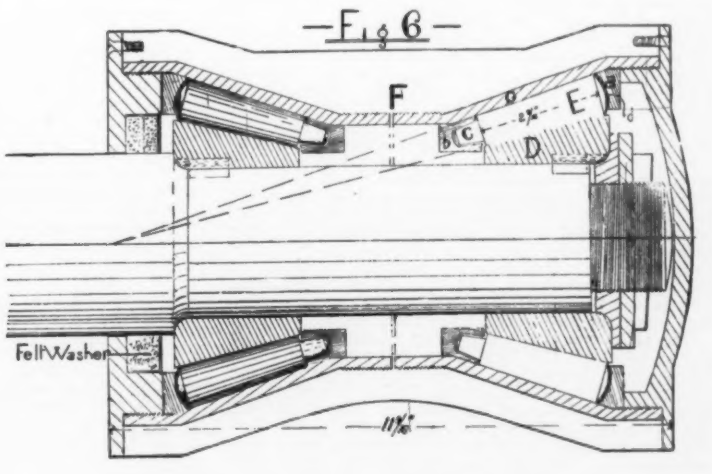


Fig. 6

* Specially prepared for the Scientific American Supplement.

ality of its maker, had little advantage over Leibnitz's machine as regards the execution of multiplications, and which for divisions was extremely cumbrous, almost useless. Moreover, its complicated structure made it quite impracticable for common use.

The autarith contains scarcely any of the parts characteristic of Leibnitz's or any other calculating machine, but was devised afresh in all details. The principle upon which the fundamental arithmetical operations are effected is borrowed from Leibnitz, it is true, but for a great number of parts, such as the devices for carrying tens and for determining the order of the result, the mathematical principle and mechanical execution had to be specially invented.

The construction of the autarith is extremely simple, each part fulfilling several functions. In consequence it is only by considerable exertion that even a specialist grasps the working principle. We do not therefore think it necessary to reprint a detailed decription of the mechanism here.

Mr. Rechnitzer's machine shows that it is not only the purely mechanical functions of the individual man which can be performed by an inanimate mechanism, but that certain mental processes even can be replaced by the work of a machine. The machine itself of course had to be devised by mental effort, and the fact that the once made mental effort suffices for the solving of an infinite number of problems is closely analogous to the fact that when once a formula is known by which one of a given type of problems is solved, all similar problems can be solved by mere substitution, without going through the development of the formula each time. The setting of the buttons in order in the autarith is nothing but the substitution of certain values in a fixed, though highly complex formula.

THE WATER SUPPLY OF LONDON.—I.

By the English Correspondent of the Scientific American.

As may be naturally supposed with a city of such magnitude as London, with its approximate six million inhabitants, the water supply essential to meet the demands of such an immense population is necessarily upon a most extensive scale. The distribution of the water is carried out by eight public companies, each of which serves a certain area of the metropolis, aggregating 620 square miles. It cannot be said, however, that the arrangement of distribution in vogue is the most conducive to economy, since there is considerable overlapping of the various sections, which would not be the case were the supply controlled by one body, such as the city or government, though by mutual agreements there is no competition or rate cutting between the eight companies.

The first London Water Company was promoted at the end of the sixteenth century, and the water was drawn from the Thames at London Bridge, by means of a curious system of waterwheels placed in the arches of London Bridge, devised by a Dutch engineer named Peter Morrys. This primitive arrangement was sufficient to meet the needs of the city for the greater part of some 240 years. The water drawn from this point on the Thames, however, was far from being pure, since the effluents from the city were discharged into the river far above London Bridge, and naturally the water was contaminated. Although the attention of the government and the city authorities was constantly drawn to this disquieting state of affairs, and the water became more and more polluted as the city grew in size, no notice whatever was taken until 1845, when the crisis was brought to a climax by the cholera outbreak. Then the danger of drawing the water from the river in the vicinity of the tidal basin was brought vividly home to the authorities, and a statute was passed in 1852 by which the eight different water companies, which had sprung into existence after the foundation of the ancient London Bridge Company, were compelled to draw their supplies from points much nearer the source of the Thames, and they were forbidden to draw any water from the river for domestic purposes below Teddington Lock, some 13 miles from the city itself.

This act of the legislature caused a revolution in the arrangement for the water supply of London, so that the present system of furnishing the metropolis with water really dates from the year 1852. Another enactment in the same statute compelled all reservoirs within five miles radius of St. Paul's Cathedral to be inclosed, or roofed in, to protect the water from impurities in the air, unless the water intended for domestic purposes is submitted to a thorough system of filtration before being passed into the mains. This last stipulation was a highly beneficial one. Reservoirs which are exposed to the atmosphere must be emptied and thoroughly scoured out twice a year, owing to the vegetation, animal life, and other impurities which accumulate therein; while in the case of reservoirs which are roofed in they need be cleansed only once in about five years, and even then they are found to be comparatively free from such pollution as existed in the exposed reservoirs. At the present time rigid precautions are taken by the law to insure the population being supplied with highly pure water.

The eight companies supplying London with water are as follows: The New River Company, the oldest in existence, dating from the seventeenth century, and which absorbed the old London Bridge Company; the East London, the Grand Junction, the West Middlesex, the Southwark and Vauxhall, the Lambeth, the Chelsea, and the Kent water-works companies. Each company serves a certain area, possesses its own system of distributing mains, and has to fulfill regulations specially devised for its own peculiar circumstances.

The water is drawn from three sources—the Rivers Thames and Lea, springs and other underground sources, and wells sunk into the chalk. Five companies draw their water entirely from the Thames; one from the Thames, Lea, and wells in the valley of the second river; one from the river Lea and wells; and the other entirely from wells. Of these supplies, that derived from the chalk is of the highest quality, being remarkably free from impurities; while that drawn from springs and other underground sources is also comparatively free from pollution, especially so far as regards suspended matter and impurities in solution.

The daily consumption of water per head in London, according to Sir Alexander Binnie, the former engineer to the London County Council, is estimated to be 35 gallons, and he opines that it will soon increase to 40 gallons. This is equivalent to a total daily consumption of over 200,000,000 gallons. The flow of the Thames varies from 1,350,000,000 gallons of water per day in the winter to 900,000,000 gallons in the dry season, and on more than one occasion the flow has sunk to as low as 333,000,000 gallons per day in times of drought. The water companies are not permitted to draw any water from the Thames should the daily volume of water passing into the tidal basin at Teddington be less than 200,000,000 gallons. This is the minimum set forth by the Thames Conservancy, which is responsible for the navigation welfare of the waterway.

London, however, is rapidly growing, and if the present rate of increase in population is maintained, there will be 12,000,000 people depending upon the London waterworks by 1931. The daily consumption will then be doubled, aggregating some 400,000,000 gallons per day. Where the additional water is to come from has been the burning question for some years past now. The water companies, however, reply that they can draw 400,000,000 gallons per day from the Thames, and still not overstep the minimum of 200,000,000 for the river, and also draw a further 225,000,000 gallons from the River Lea, wells, and other various sources. But at the same time, it is perfectly apparent that if the Thames flow falls as low as 333,000,000 gallons per day, the companies will not be able to draw their requisite 400,000,000 gallons and still leave 200,000,000 in the river as required by law. To cope with such emergency, a huge storage reservoir has been built at Staines near London, with a capacity of 3,333,000,000 gallons, to be reserved for use when the daily supply from the Thames becomes deficient. These tremendous works were fully described in the Scientific American a few weeks ago.

Having described the general system of London's water supply, we will proceed to deal with the share of each of the eight companies participating therein, since each company possesses several distinguishing features, and carries out its own arrangements to meet the demands of the particular area of the city it supplies.

The largest, and at the same time the oldest, of these water companies is the New River Waterworks. This concern was inaugurated on September 29, 1613, by Sir Hugh Middleton, a well-known civil engineer of the period. By his scheme the water was tapped at Chadwell Spring near Ware, about 30 miles from London, and even now this spring forms one of the principal sources of supply for the company. He constructed a small river—from which the company derives its name—for the conveyance of water to the city. At a short distance below the spring a branch has been made connecting it with the River Lea, by which additional water is obtained, the flow being controlled and regulated by a floating gage placed at the upper end of the cut. In conveying the water from the source to the metropolis, Sir Hugh Middleton followed the contour of the ground, to avoid the construction of embankments, aqueducts, or tunnels, so that the course of the new river under these circumstances was necessarily rather long—approximately 40 miles in length. This, however, was a commendable engineering enterprise at the time. But the length of the river has since been reduced to 28 miles by straightening the course of the waterway, constructing aqueducts, tunnels, etc., and the watershed through which the river runs has been further tapped at various places by sinking wells supplied with heavy pumping machinery to raise the water from the extensive subterranean reservoirs in the chalk bed to the river. The power of the pumping machinery varies with the depth of the well and the quantity of water to be raised, ranging from a 16 horse power engine to one of 200 horse power. The reservoirs are freely distributed throughout the area supplied by the company.

In the metropolis itself at Clerkenwell, upon the borders of the city, the head of the new river, is a subsiding reservoir for unfiltered water, three-fourths of an acre in area, with a total capacity of 700,000 gallons, and there are also three filtering beds of an aggregate area of 2¼ acres. Clerkenwell is the headquarters of the company, and here are situated the various offices for the control of the affairs of the company, business, storehouses, engineers' shops, and so forth.

The largest reservoirs are at Stoke Newington, where there are two subsiding reservoirs covering 42½ acres of ground and with a total capacity of 90,000,000 gallons. The filter beds, of which there are nine, cover nine acres, and there are seven pumping engines, aggregating 1,080 horse power.

The following is a list of the various reservoirs and the respective purposes for which they are reserved, together with the filtering arrangements:

Station.	Type of reservoir.	Area.	Capacity in gallons.	No. of filter beds.	Area.
		Acres			Acres.
Cheshunt ...	2 storage, unfiltered	18¾	30,000,000	...	...
Hornsey.....	2 subsiding "	8½	8,500,000	8	5¼
Pentonville...	1 storage, filtered	8½	3,500,000	...	...
Hampstead ..	1 " "	8½	500,000	...	...
Maiden Lane.	2 " "	8½	15,000,000	...	...
Highgate Hill	1 " "	8½	1,000,000	...	...
Hornsey Lane	1 " "	8½	3,000,000	...	...
Crouch Hill..	2 " "	8½	12,000,000	...	...
Edmonton.....	1 " "	8½	1,500,000	...	...
Southgate.....	1 " "	8½	1,000,000	...	...

In addition to the foregoing there are three other reservoirs, aggregating approximately 40,000,000 gallons, for unfiltered water. This is not for domestic use, however, but solely for street watering and trade purposes.

At many of these reservoir stations are wells from which additional water is obtained, and each station is supplied with adequate and suitable pumping machinery. The New River Company are not restricted in connection with the volume of water which they may draw from the River Lea every day, as is the case with those companies which depend upon the River Thames for their supply.

Another ancient company was the Shadwell Waterworks, which came into existence in 1669 for supplying the East End of London with water. This company, however, was absorbed by the East London Waterworks, which was founded in 1807, and, as its name implies, it distributes its water throughout the East End of the metropolis. The first reservoirs were built about 1808 and were of the settling type, and covered an area of approximately 11 acres.

This company derives its water from four sources—the River Lea, the intake for which is located at Chingford, about 10 miles east of London; from deep wells bored into the chalk; the River Thames at Sunbury, about 16 miles west of the metropolis; and from springs at Hanworth.

The principal source of supply, however, is the River Lea. The intake is situated at Chingford. A well and borehole have also been sunk into the chalk, and the water is lifted 350 feet by two Guard turbines, while a compound steam engine is held in reserve for employment when the water power is unavailable owing to floods.

From the intake at Chingford the water is conveyed to Walthamstow, the main reservoir of the whole company, through two brick tunnels and an open channel feeding the high and low reservoirs respectively. There are ten of these reservoirs, covering a total area of 316 acres. They are perfectly open, and resemble huge lakes or sheets of laid-out ornamental water, being studded with well-wooded islands which render the whole aspect very charming. The total capacity of these reservoirs is 1,200,000,000 gallons. The filtering beds are located at Lea Bridge, and the water stored at Walthamstow gravitates thereto. The filter beds are 34 in number, covering some 31 acres. The filtering material, which is 3 feet, 6 inches, in total thickness consists of 2 feet of sand, 6 inches of hoggin, and 1 foot of coarse gravel.

After filtration the water passes to the storage reservoirs at Old Ford through 4-foot cast-iron pipes. This storage reservoir, which is covered in, has a capacity of 1,500,000 gallons, and the water is distributed into the supply pipes and main by a large plant aggregating more than 870 horse power. This station is of special interest from an engineering point of view, since it was here that the first Cornish pumping engine, a great improvement upon the engines then in vogue for the work, was erected in London. A well is also sunk into the chalk for a depth of 450 feet at this station, and the water derived therefrom is pumped and mixed with the filtered water in the reservoir.

At Woodford there are also two covered reservoirs of 3,000,000 gallons, while at Buckhurst Hill there is a water tower, the tank of which contains 70,000 gallons and supplies the immediate neighborhood. At Hornsey Wood is another huge covered-in reservoir of 5,000,000 gallons, but this receives water from the Thames as well as the River Lea.

The Thames supply for the East London Waterworks is taken at Sunbury on the north bank, and the water is pumped to Hanworth, two miles distant, by pumping engines. The Thames water is received at Hanworth in an open reservoir of about 5,000,000 gallons capacity, and then flows to the filter beds, six in number and covering five acres, similar in construction to those of Lea Bridge. After filtration the water is stored in two covered-in reservoirs aggregating 2,500,000 gallons, and thence the water is conveyed through some 19 miles of 3-foot mains to the Hornsey Wood reservoir, from where it is distributed.

The West Middlesex Company also draws its water from the Thames, the intake being at Hampton. The water flows from the river through fine screens into the engine wells. The water then passes on to Barnes through 3-foot mains—it passes under the river again *en route*—to four subsidence reservoirs at Barnes with an aggregate capacity of 117,500,000 gallons. The filter beds are also located here, through which the water passes before it is conveyed to the distributing station at Hammersmith. The filtering medium of these beds, of 7 feet, 6 inches, thickness, comprises 2 feet, 3 inches, of Thames sand, 3 feet of Barnes sand, and 2 feet, 3 inches, of gravel of varying coarseness. The collecting drains are pierced earthenware pipes placed 2 feet apart upon the bottom of the beds. The water is stored in covered reservoirs at Campden Hill, Barrow Hill, and Kildepore, the capacity of each being 3,672,000 gallons, 4,750,000 gallons, and 2,500,000 gallons respectively.

(To be continued.)

A PROPOSED SOUDAN RAILROAD.

A complete railroad system is to be carried out in the Soudan for the development and opening of the country. The first scheme is to connect Khartoum with the Red Sea at Suakim. The shortest route connecting the Nile with the Red Sea is over the ancient caravan route, via Berber to Suakim, but it is improbable that this route will be selected for the railroad, as the country between Berber and Suakim is largely arid desert practically uninhabited, and presents many serious engineering difficulties. The preferable route is from Khartoum to Kassala, thence north to Suakim. This line would follow established trade routes, traverse fertile country, and would form an important link in the railway to Uganda and Mombasa. By the recent treaty with Emperor Menelik, the British and Soudan governments have acquired the right to construct a railroad through Abyssinia, to connect the Soudan with Uganda. It is not, however, intended that the railroad should climb the Ethiopian tableland, but to avoid the Nile swamps shall cross the territory transferred to Menelik by the treaty. Under these circumstances the railroad when constructed will be of benefit to both nations. According to present plans, the railroad will run from Kassala south to Gedaref, and thence to Roseires on the Blue Nile. From Roseires the railroad, skirting the Abyssinian encampment, will go south to Itang, an Abyssinian settlement nestling at the foot of the hills on the Baro River, an affluent of the Sobat. From Itang

the line will be carried to Lake Rudolf, from the southern extremity of which to the nearest point of the existing Mombassa-Victoria Nyanza Railway is about one hundred miles.

THE JOINT TRANSMISSION OF DIFFERING CURRENTS.*

FREDERICK BEDELL.

THIS is an era of combination. The particular combination to which I invite your attention this evening is a combination between the one-time rivals Direct and Alternating Currents. In fact the combination is far more reaching, for alternating currents of different frequencies may be combined, and so too may power transmission currents and currents for the transmission of intelligence. The same system of conductors may supply our alternating lamps and our direct current motor. We may remove an incandescent lamp, attach a telephone and talk over the incandescent circuit with our neighbor.

This method of telephoning or telegraphing over electric light and power circuits, let us pass with this casual mention and proceed to consider the joint transmission of differing currents for electric light and power.

An important characteristic of differing currents is their non-interference. Assigning personality to the currents, we may say that Current A when traversing a wire does not know that Current B is there, the two being of different character. Neither current recognizes the existence of the other, and is in no wise affected by its presence or absence. To illustrate the extreme to which this is true, we may refer to the experiment, which some of you have tried and others may try in the laboratory, of telephoning over a power circuit from which motors are operated. The starting and stopping of the motors does not affect the telephone.

For power transmission this non-interference leads to two important results, a great economy of copper and a lamp regulation not affected by motor load.

Copper Economy.—In the joint transmission of differing currents each current has the entire benefit of the whole conductor as though that current were transmitted alone. This means that for the transmission of two currents the same amount of copper is required as for the transmission of one alone; that is, twice as much power may be transmitted with a given amount of copper. Hence there is a copper saving of fifty per cent.†

Consider the case of one incandescent lamp furnished with a direct current of one ampere over a conductor with a resistance of one ohm. The line loss for one lamp is one watt. Let a second incandescent lamp be supplied with one ampere of alternating current. In the line conductor, the one ampere of direct and one ampere of alternating current combine to make a resultant current of only 1.414 amperes. The line loss is now two watts for two lamps, or one watt per lamp as before. Each current has a loss of one watt the same as though the other current was not there.

If the two lamps were supplied with like current, one ampere each, the total current would be two amperes with a line loss of four watts. To reduce the line loss to two watts (its value with differing currents) the line resistance would have to be reduced to one-half; to accomplish this twice as much copper would be necessary. Single current transmission requires twice as much copper as double current transmission.

Independence of Lamp and Motor Regulation.—We have just seen that line losses‡ for differing currents transmitted jointly are independent of each other; whereas this independence is not found for like currents. What is true for line losses is equally true for line drop. The line drop for each current is equal to the line loss for that current divided by the value of that current. The regulation for each of two differing currents is accordingly independent of the regulation of the other.

In all systems employing but one kind of current the lamp regulation is affected by the motor load. With differing currents, the lamp and motor regulation may be made entirely independent. The motor service may be increased far beyond that originally contemplated, each motor overloaded as much as it can stand, the line drop for the motors increased to any amount you will, and the regulation of the lamps will remain unaffected. This feature, aside from its general utility, is of particular value in service furnished to outlying districts.

General Advantages.—The fundamental advantages in joint transmission are those just discussed—simplicity, copper economy and independence of lamp and motor regulation. These lead to the further advantages:

General Economy.—In addition to economy in first cost, the reduction of fifty per cent in the copper employed in feeders and mains of a distribution system reduces the cost of maintenance, inasmuch as it simplifies the system and reduces subway construction, poles, lines, switching devices, etc.

Extension of Kind of Service.—Motors and lights may be offered to consumers, where otherwise only one kind of service could be satisfactorily and profitably maintained.

Improvement in Quality of Service on account of independence of lamp regulation.

Extension of Economical Area of Distribution.—This is rendered possible on account of the copper economy. In some cases the area may be extended on account of the income from the added motor service which otherwise would not be possible.

Different Voltages for Lamps and Motors.—The voltage of incandescent lamps is lower than is generally desirable for motor operation. With the two classes of service supplied by joint transmission, each class may be supplied with current at the pressure and with the degree of regulation best suited for it under the conditions. Thus the motors may be operated at 440 volts and the lamps at 110 volts.

Systems of Transmission.—To obtain the benefits recited above it is required that a system be employed for the joint transmission and separate utilization of differing currents. The separation of the currents for their utilization is as necessary as the combination of the currents in transmission. The systems* by which these results may be obtained may be classified as follows:

(a) Selective.
(b) Differential.
(c) Common conductor.

(a) Selective System.—In solving the problem it is natural to first consider the employment of selective devices or traps permitting the passage of one form of current and restraining the other. This system can be worked to a limited extent. Try it and you are likely to soon conclude that its commercial applicability is questionable. When direct and alternating currents are transmitted by this system a serious problem arises in preventing the saturation of the iron cores of alternating current coils by the passage of direct current. But even with all difficulties overcome, the need of special devices is a serious objection. For commercial success the separation of the currents must be obtained as an inherent characteristic of the system.

(b) Differential System.—In this system one form of current (e. g., direct) flows differentially through the coils of apparatus utilized by the other current (e. g., transformer coils), so that no magnetizing action is obtained. This method many of you have used in the Dynamo Laboratory in performing the experiment entitled† "Starting a Rotary Converter by Means of Direct Current Transmitted over the Alternating Line." The complete separation of the two currents by this system is illustrated by the telephone experiment referred to above.

For primary transmission the differential system is the proper one to use. By means of this system direct current may be transmitted for special purposes over alternating current transmission lines, either single-phase or polyphase. An interesting field lies in the joint primary transmission by this system of alternating currents of different frequencies, one for light and one for power; these may be single-phase or polyphase. The lamp regulation is thus independent of motor load.

For secondary distribution it is preferable to employ the differential system only in connection with the Common Conductor System.

(c) Common Conductor System.—This system is adapted to secondary distribution for which it is especially suited on account of its simplicity, as well as the copper saving and improved lamp regulation already discussed. Four main wires, 1, 2, 3, 4 are employed, only two of which need enter any consumer's premises, or need be employed in any particular street or district. The separate pairs of wires are used as follows:

Lines 1 and 2 supply direct current devices.
Lines 2 and 3 supply alternating current devices.
Lines 3 and 4 supply direct current devices.
Lines 4 and 1 supply alternating current devices.

All receiving devices are directly connected and no special apparatus is required.

Existing systems may be utilized without change to obtain the advantage of joint transmission. Consider lines 1, 2 to be the main conductors of an existing Edison system supplying 100 lamps. The addition of lines 3, 4 permits the wiring of 300 additional lamps (instead of 100 additional lamps as at present). Doubling the copper increases the lamps supplied four fold without disturbing the existing system.

The three-wire system may be used. The addition of a neutral wire for each pair makes it possible to employ the three-wire system together with the common conductor system. The two systems are not alternative.

For isolated plants and office buildings the common conductor system should be used for connecting receiving devices. At the generating plant a combination with the differential system may be employed so that only one double-current generator need be employed. The A. C. brushes connect with the primary of a transformer with two equal secondaries. The four secondary terminals form the four wires of the common conductor system. The two leads from the D. C. brushes are connected respectively to the middle points of the two secondaries. From this it is not to be understood that the use of a double-current generator is necessary; separate sources for direct and alternating currents may be employed when desired.

For sub-station work one rotary converter may be connected in a somewhat similar manner.

Voltage in Primary Distribution.—By the differential system of connection, in any usual case direct current transmitted over primary lines will not increase the line voltage.‡

In the joint transmission of high potential currents of different frequencies, the line voltage is raised. Hence on the basis of a limiting voltage between conductors the copper saving is reduced from a saving of fifty per cent to a lesser amount according to the particular way in which the differential method is applied. Thus in one case on the basis of a definite potential between conductors the copper required§ in transmitting currents of different frequencies is nine-tenths of that required for the transmission of three-phase current of one frequency. The advantage of copper saving is accordingly not so great. The advantage of independent lamp regulation is fully obtained.

Voltage in Secondary Distribution.—Referring to the paragraph on the common conductor system, if the receiving devices be for 100 volts, the lines brought into each consumer's premises will be at a pressure of 100 volts. In the distributing system lines 1, 2; lines 2, 3; lines 3, 4; lines 4, 1 will have a difference of potential of 100 volts. There will be a difference in pressure of 141 volts between lines 1 and 3 and between lines 2 and 4. These lines may be remote. So far as copper saving is concerned we obtain all the advantages of transmitting at one voltage (say 141 or 282), and receiving without transformers or auxiliary devices at seventy per cent of that voltage (say 100 or 200 volts). We obtain the same benefit, so far as copper economy is concerned, as though each consumer were given a 10:7 transformer.

Such a transformer, however, would not give the advantage of independent lamp regulation which is obtained by the system under discussion.

Conclusion.—A careful study of the problem of joint transmission for a particular set of conditions will suggest details and modifications tending toward economy and improved service which have not been discussed in this brief paper. In this brief outline enough of the characteristics of joint transmission have been touched upon to show the utility of such a system. Although the writer has devoted a great deal of attention to the subject for several years, new phases of the subject are continually developing. It is a broad field and an attractive one on account of the variety, as well as the vastness, of its engineering possibilities.

* Abstract of a paper read before the Electrical Society of Cornell University, February 2, 1903.

† Discussed fully by the writer in a paper entitled "Copper Saving in the Joint Transmission of Direct and Alternating Currents," Sibley Journal, Vol. XV, No. 1.

‡ Proved rigorously in reference cited.

* These were fully described with black-board illustration.

† See article under this title, Sibley Journal of Engineering, Vol. XIV, No. 9, p. 409.

‡ In a single-phase system with D. C. connected between the neutral point and an auxiliary conductor (or ground) the virtual value of potential between any two conductors is not raised unless the D. C. pressure exceeds 0.866 of the A. C. pressure. In a three-phase system similarly connected, the potential between conductors is not raised unless the D. C. pressure exceeds 0.81 of the A. C. In a four-wire two-phase system with direct current connected between the neutral points of the two independent phases, this percentage becomes 0.707. Usually the direct current will be at a pressure much lower than that indicated in any of these cases.

§ The case taken is one in which each of the three conductors of a three-phase system is split into three lines, each of these three groups itself constituting an independent three-phase system of different frequency.

THE GLASS PEDESTALS OF CLEOPATRA'S NEEDLES.

DR. A. J. BUTLER, the well-known English Egyptologist, has published some interesting facts concerning the famous Egyptian monument known as Cleopatra's Needle, now on the Thames Embankment, London, and the sister monolith in this city. These obelisks, it will be remembered, were originally taken from Heliopolis to Alexandria by command of Augustus. They stood in the forecourt of the temple begun by Julius Cæsar, and completed by Augustus, known as the Cæsarion, afterward transformed by Constantine the Great into a Christian church. When the Arabs invaded Alexandria in 642 A. D. they manifested deep interest in the needles, which, by the way, are fashioned out of Assouan red granite, and they confused them with the lighthouse of Pharos, and said that it was erected upon a foundation of glass formed like a crab with images of brass crowning it. Dr. Butler, from the result of his investigation, states that the obelisks did stand on crabs, since when the monolith at present in this city was removed from its position, it was found resting on four huge metal crabs which held it clear of the pedestal, the latter consisting of a single block of granite, which in its turn was supported upon three graduated courses of stone. Dr. Butler is also of opinion that although the Arabs may not have been actually correct in stating that the monoliths were built on glass foundations, there is every probability that they rested on the mineral known as obsidian, which is extremely hard, and has a brilliant polish, and so resembles glass that it is often defined as a natural form of the latter product.

PLATINUM EXTRACTION IN THE URAL REGION.

PROF. DEMARET-FRESON has lately published some interesting facts in regard to the production of platinum. Within the last few years the applications of this metal, especially in the electrical industries, have rapidly increased, while the production remains about stationary, and it is estimated that the entire world's production is not over 7 tons annually. It is owing to this cause that there has been a considerable rise in the price of platinum. The metal is generally found in alluvial layers of sand and gravel near the watercourses, in the bottom of valleys or on the hillsides. It generally occurs in the form of flattened grains with either a rough or smooth surface. Nuggets are also found, but these are more rare. Russia furnishes about 96 per cent of all the platinum produced. It is found especially in the Ural region, the most productive locality being in the government of Perm. The placers are situated on the crest of the mountain chain or on the two sides. On the European side they lie along the rivers Vilva and Kava and along the Otka and other streams. Many of the rich placers lie in the domains of Prince Demidoff, and on one occasion a nugget was found there which weighed 22 pounds. The platinum-bearing strata are often 15 feet in thickness, but as they are often sunk as low as 60 feet below the surface they must be reached by a series of shafts and galleries. On the Asiatic side are found the gold and platinum-bearing sands of the Miass River and other streams of the region. The richest deposits yield from 60 to 90 grains of platinum per ton, while this proportion varies down to 40 grains. The metal is generally found along with gold in most of these regions, and both are extracted by a somewhat primitive method. When the material is of a clayey nature it is charged in a barrel-shaped wooden receptacle about 6 feet high and 8 feet in diameter whose bottom is covered with perforated sheet-iron. Into the cylinder is fed a number of streams of water from a pipe which encircles the mouth. In the center turns a vertical shaft carrying a series of arms which support iron bars for working the material. In this way a muddy deposit containing the metal sinks to the bottom and passes out through the holes; it is run on to an inclined table or shallow trough 3 feet wide and 10 feet long in which are retained the platinum grains. In other cases, when the material is sand or gravel, a simple cylindrical sieve is used instead of the cylinder and, like it, is supplied with streams of water.

When the placers are found in the river bed or in submerged ground, the peasants employ a primitive method of dredging. Mounted on a raft, they operate a wood scoop through an opening in the center. The scoop is on the end of a pole 12 feet long, and is brought up by a chain wound on a windlass. The sand and gravel is poured on a sieve which is mounted above a kind of cradle placed on the raft itself; it is fed with water from a hand pump. The material obtained by these processes is further enriched by a second washing, and the platinum is separated by treatment with mercury, which amalgamates with the gold but does not attack the platinum, and the residue containing the latter is sent to the refineries. The residue obtained in the Ural region contains on an

average 87.25 per cent platinum, 1.20 of rhodium, 0.05 of iridium, 0.01 of osmium, 1.04 of palladium, besides 1.50 of osmium-iridium alloy; it also contains 8.40 of iron and 0.55 of copper. To extract the platinum from the mixture the wet process is generally used; it is treated with aqua regia, and the solution thus obtained is precipitated by chloride of ammonium in the form of a double chloride. The latter is calcined and the resulting product may contain 99.9 per cent of platinum. In some cases the electric method is employed to separate the platinum from the iridium and rhodium. A rather weak current is used, the electrolyte being an acid solution of platinum chloride.

PROGRESS OF THE BEET-SUGAR INDUSTRY IN THE UNITED STATES.*

By CHARLES F. SAYLOR.

INTRODUCTION.

THE production of sugar beets and of beet sugar in the United States is now assuming such proportions that, with the increase of factories and the marked popular interest, it has become one of the leading subjects demanding consideration from agriculturists. There is probably no other industry in this country that has developed so rapidly and now absorbs so large a share of public attention as that of beet sugar.

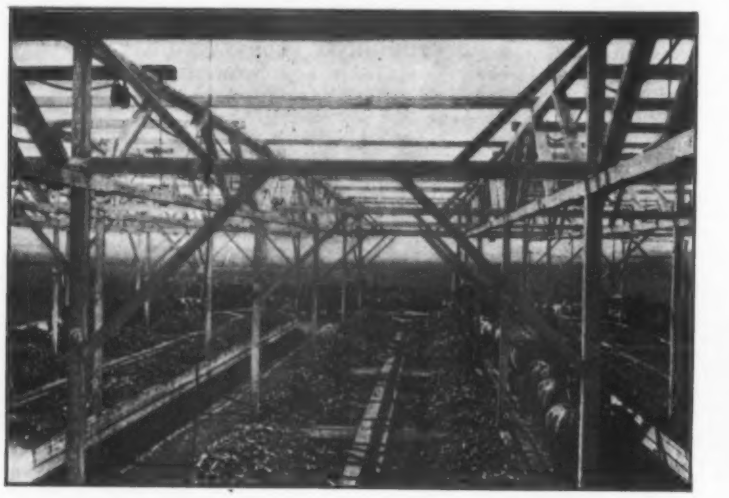


FIG. 1.—LOADED WAGONS ENTERING RECEIVING SHED AT BEET-SUGAR FACTORY. OXNARD, CAL.

FIG. 2.—TRAIN LOAD OF SUGAR BEETS. OXNARD, CAL.

FIRST ATTEMPTS TO START THE BEET-SUGAR INDUSTRY.

Attempts were made to establish the beet-sugar industry in Massachusetts some sixty-two years ago. There were also efforts in this direction in Illinois, Wisconsin, and California between the years 1863 and 1876, and much was claimed for the industry at this time by newspaper writers, capitalists, and leading farmers. In California, after a long period of unprofitable production, the industry achieved its first success. The failure of these early attempts seems now very natural as we look back over the history of agricultural progress in the United States. The beet-sugar industry belongs to the domain of agriculture, and the problems it presents are agricultural. These early efforts were simply ahead of their time in the course of agricultural development, and they failed in the establishment of the beet-sugar industry for want of the proper methods of farming and the proper conditions underlying the farming industry.

FIG. 3.—PREPARING THE LAND FOR BEETS. SAN RAMON VALLEY, CAL.

FIG. 4.—HARVESTING SUGAR BEETS. SAN RAMON VALLEY, CAL.

DEVELOPMENT OF FAVORABLE CONDITIONS FOR BEET-SUGAR INDUSTRY.

At the time of the first attempts at sugar-beet production agriculture comprehended simply the primary features. Its products were confined mainly to cereals, forage crops, and live stock, and the production and marketing of raw materials was its main object. The farmer in those early days did not concern himself with enterprises dependent on the concentration of efforts in the production of finished products. Land could be purchased for a few dollars per acre. If the prospective farmer did not have the money to buy the land he could enter a claim on government land. His whole ambition was to produce something quickly and pay for the lands and primary improvements. This was accomplished by raising corn, wheat, oats, cattle, and hogs. The open public domain offered a free pasture. Gradually the eastern sections became more densely settled, and farm lands became more expensive. Crude production was accomplished more cheaply by the western farmer. Later, owing to development of transportation facilities, the agriculture of this country had to compete with the cheap labor of Europe. The colonial extension of European countries brought areas into competition with American farms in turning out crude products, and with labor much cheaper even than that of Europe. The problem became, how to turn crude material into something that would represent not merely the labor but the skill and ingenuity of the American people, thus supplying our own markets and those of the world with finished products. The American farmers found, as the manufacturers had found before them, that their success depended upon the superior skill and artisan ability of Americans as compared with Europeans and their colonists. "Necessity is the mother of invention," and demand and necessity united in the evolution of a new system. This began in the East, working westward, in the production of butter, cheese, prepared meats, flour, eggs, poultry, etc. Later came the establishment of other industries, working up crude products of the farm into finished articles. We became producers of sirups, canned vegetables, canned fruits, etc., until manufacturing reinforced farming from ocean to ocean. When all this was accomplished the time was ripe for the success of the beet-sugar industry.

INDUSTRIAL FEATURES OF THE UNITED STATES.

It is one of the marked features of American industrial life that the people as a mass have always shown a readiness to forego immediate benefits and, even at considerable expense to themselves, to encourage industrial development. As a result, this country has made a record among the nations of the earth unparalleled in rapid development, accumulation of wealth, and hold on the trade of the world.

One of the chief items of cost in the production of anything is labor. In this country it is contended that the laborer is not only entitled to earn a living, but to live comfortably, to be able to educate his family, and to acquire a comfortable home. There is no position in life, social, financial, or political, to which the laboring man may not aspire. While this means much for the citizen, it adds materially to the cost of production. This country to-day is the concern of the nations of the earth in being able to maintain a balance of trade in its favor through its agricultural and industrial productions, and this balance is constantly increasing. The sugar industry is supported by American enterprise and spirit, and under this American policy it is rapidly assuming a prominent position in the long list of successful industries.

PROBLEMS FOR THE FARMER IN GROWING SUGAR BEETS.

There are two sides to the proposition of establishing a sugar factory in any particular community: (1) That of the farmer, involving agricultural conditions, and (2) that of the manufacturer or those financially interested in the enterprise.

Methods Employed in Growing Sugar Beets.—The leading difficulties of the farmer may first be noticed. To begin with, he is unacquainted with the methods of cultivating the sugar-beet plant, and his first experience usually proves unsatisfactory. He is accustomed to certain methods in farming. As a rule, he is conservative, and thinks, from his long experience in farming, that he knows how to farm. He undertakes to apply methods successful in the cultivation and production of other crops. He is not inclined to listen to those who are posted in methods applicable to the new crop. Eventually he finds out his mistake. He finds that in growing sugar beets he must apply principles, in many cases, the reverse of those necessary to other crops. For instance, he has been accustomed to growing large ears of corn, large hogs, and large steers; but in the case of sugar beets he finds that the first question is not one of size, but of quality. He must grow beets of a certain size, purity, and sugar content. In order to accomplish this he must give careful attention to the work of preparing the land, planting the seed, bunching, thinning, and cultivating. He finds that attention to details counts in results at the harvest in the profits on the crop. He learns that the whole process is a very laborious and expensive one, entirely unlike anything he has attempted before. To be successful he must apply the methods of the gardener to a field crop. He must have a rich soil and the proper rain conditions at the proper time. These facts can only be learned through experience.

The Question of Labor.—The labor problem is important in the cultivation of sugar beets. At certain stages of their growth sugar beets require a considerable amount of labor. This labor is very tiresome. As a rule, the farmer, if he grows beets to any extent, does not have on his farm sufficient labor to do the work of thinning and bunching, hoeing, and harvesting the sugar beets; nor does any farming community possess to any considerable extent the labor necessary to grow the beets that a factory will require in a campaign. It will cost about $30 an acre in sections where sugar beets are grown under rainy conditions, and about $40 to $45 an acre in sections where beets are grown by irrigation, to cover the cost of seed, preparation of seed bed, bunching and thinning, hoeing, cultivating, harvesting, and delivering to the factory. These estimates apply to growing sugar beets when it is properly done. In the farming communities of foreign countries, as a rule, a large amount of suitable labor can be secured in the neighborhood, because these neighborhoods are more thickly settled; the whole population is willing to do the laborious, tedious work required, and whole families work at it, including the father, mother, and children. In this country, as a rule, the farmer, his older sons, and hired hands must attend to the outdoor work. It has been found necessary for sugar-beet growers to resort to the cities and towns for the extra labor required. Most of this work comes about the time the public schools are closed, and boys from 12 years up are employed for bunching and thinning the beets, for hoeing them during the season, and to aid in the harvesting by pulling, cleaving the tops, and loading the beets into wagons. In the cities also live many foreigners from Holland, Russia, Sweden, and other places

* Yearbook of the Department of Agriculture, 1901.

who are thoroughly familiar with this kind of work. These people are willing to move out into the fields and live in tents; they make contracts at so much per acre for bunching and thinning, hoeing, weeding, and harvesting. Since the agitation and starting of the beet-sugar industry in this country, foreigners are coming here with a view to securing employment of this kind. While the labor question is a serious one, it is one capable of solution by careful and detailed attention.

PROBLEMS FOR THE MANUFACTURER IN THE BEET-SUGAR INDUSTRY.

The manufacturer or the capitalist who builds a factory finds that he has even more problems to work out than the farmer, and, like the farmer, he usually discovers that he is entering a field that is entirely new to him. Before establishing his plant the prospective manufacturer must thoroughly investigate certain conditions: (1) The water supply, for he must have an abundant supply of pure water for the use of the factory. (2) The fuel supply, as the factory must be located in a section where cheap fuel can be secured (the fuel usually used is coal, but on the Pacific coast petroleum is used to a large extent, and in some of the mountain States it is found that wood is the cheapest fuel). (3) A market for the product (this factor should be thoroughly canvassed and settled prior to establishing a factory; the fact that the manufacturer is proposing to establish a factory on a particular line of railroad can generally be used to secure by contract low freight rates for the future both in shipping beets and the finished product—sugar). (4) The supply of lime (the local quarries of lime rock must be investigated to see if the quality is suitable and the supply sufficient, as a large amount will be required).

The general conditions having been found satisfactory, and the factory being built, other problems arise. In the beginning only a limited amount of skilled labor is employed. Eventually every employe of the factory will become skilled in his particular part. After two or three campaigns have passed the factory will have worked out the details of producing the best product at the least cost with the machinery which it has. When this point shall have been reached those interested will be prepared to estimate the cost of production of beet sugar. The difference in cost of production at a new factory and at one operated for a considerable time is much greater than one unacquainted with the subject would suppose.

STATISTICS OF GROWTH OF THE BEET-SUGAR INDUSTRY.

The recent census shows the rapid growth of the beet-sugar industry in this country. Thirty-one factories had been established before the end of the century. Since that time 11 other factories have been put in operation, located at the following places and having the daily capacities named: Lyons, N. Y., 600 tons; Rockyford, Colo., 1,000 tons; Sugar City, Colo., 500 tons; Bingham Junction, Utah, 350 tons; Provo, Utah, 350 tons; Lansing, Mich., 600 tons; Saginaw, Mich., 600 tons; Salzburg, Mich., 400 tons; Loveland, Colo., 1,000 tons; Menomonee Falls, Wis., 500 tons; and Logan, Utah, 400 tons.

At the following places factories are either in process of erection or preparations have been made for building in 1902: Sebewaing, Mich., 600 tons; Carrollton, Mich., 600 tons; Mount Clemens, Mich., 600 tons; Crosswell, Mich., 600 tons; Greeley, Colo., 800 tons; Eaton, Colo., 500 tons; Fort Collins, Colo., 500 tons.

At the following places companies have been organized and capitalized, and there is every indication that they will mature their plans and erect factories in time to engage in the beet-sugar campaign of 1902 or 1903: Saginaw, Mich., two factories, 500 tons each; Chesaning, Mich.; Badaxe, Mich.; Grand Rapids, Mich.; Lapeer, Mich.; Sioux City, Iowa; Longmont, Colo.; Lamar, Colo.; Bear River Valley, Utah; Phoenix, Ariz.; Cheyenne, Wyo.; Los Angeles, Cal.

At many other places preliminary organizations have been formed which are only awaiting developments assuring more settled conditions affecting the sugar industry.

METHODS OF GROWING SUGAR BEETS.

It would be quite difficult to give general directions and rules for growing sugar beets applicable to all localities and conditions. Often expert sugar-beet growers, at public meetings and in the agricultural press, give minute directions covering all the details of this intricate process. Others, each well versed in the process of growing sugar beets, get into arguments and disputes as to the right method. In such cases each may be correct in a measure. The occasion for such disagreements lies in the fact that each person has in mind the right method for a particular locality or set of conditions. A careful study of the different sections of the United States where sugar beets are grown will lead to the conclusion that there is no single road to success in growing sugar beets. Every locality has settled conditions which will materially modify any set of methods that might apply to some other one. There are some settled rules, of course, but it is an actual fact that the various agricultural districts of this country will have to work out each for itself the right method. The person who argues that the ground must be plowed in the fall in order to receive the benefit of winter frosts is not offering any argument to the Pacific coast, for instance, where many beets are grown, and he who insists that the ground should be rolled in all instances after planting will hazard the crop if his directions are followed in many parts of Nebraska and other sections where the soil is sandy and there are strong winds. In such cases a smooth surface offers an excellent opportunity for the wind to carry along the sharp grains of sand, cutting off the plants and destroying the crop.

There can be no general fixed rules applying to the kinds and application of fertilizers. General principles are all right when accompanied with the underlying reasons, but must always be modified to meet local conditions.

With the development of the industry in all the sections which have the necessary conditions, and the acquirement of ample experience both by the farmers in the production of beets and by manufacturers in the making of sugar, there will come many improvements, and eventually a cheapening of production, a result of great importance to all concerned in the success of the industry, because eventually the beet-sugar industry of the United States will have to meet a sharper competition with foreign sugar producers.

There are some things settled, however, about growing sugar beets. It will generally be conceded that the ground should be plowed deep, and in most instances subsoiled. Before the seed is planted, the ground must be thoroughly pulverized by harrowing and by rolling, even if the surface has to be afterward roughened. Advantage must be taken of the general and prevalent rain conditions. The ground must be moist enough to germinate the seed, either by rainfall or irrigation. Rainfall is best when it can be obtained. In some localities either is used, according to circumstances. Seeds are planted at depths of from one-half inch to 2 inches, according to the prevailing conditions in the particular locality. The beets must be planted near enough together to produce a beet of a certain size. This spacing depends, again, upon the locality and the nature and fertility of the soil. The size and quality of the beet depend materially on the right kind of spacing. The beets must be thoroughly cultivated, hoed, and hand weeded, because cultivation tends to conserve the moisture of the soil and clean fields permit favorable action of sun and air. This close cultivation should be kept up until the beet tops thoroughly shade the ground and reach a size when it would be injurious to operate among them further with a plow and hoe. The beets should be harvested as soon as possible after they are ripe, because then they contain the most sugar and the highest purity. It is evident that the entire crop of beets in the neighborhod of a factory cannot be harvested at once. In many localities some will have to be siloed. Harvesting time will depend a great deal upon circumstances connected with the operation of the factory. The sooner the beet is harvested after it is ripe the better, because further rainfall may start a new growth, producing new lateral roots and new leaves, thus greatly reducing the sugar content and purity of the beets.

BENEFITS TO THE FARMER GROWING SUGAR BEETS.

No statement of facts with reference to any new crop would be complete or would indicate the advisability of its introduction unless it showed the benefits to be derived. Of course, profit and loss in any enterprise is the first consideration.

It has already been stated that it costs about $30 per acre to produce sugar beets and to market the crop where rain conditions prevail. This is without taking into consideration the rent of the land, but it includes the farmer's time and everything else that enters into the cost of production. The average yield is about 12 tons per acre. Probably this cost of production will be gradually reduced because of improvements in implements and methods. The beets grown have a gross value at the factories of $4 to $4.50 per ton (in States paying no bounty). This gives a gross return per acre of $48 to $54, and a net profit of $18 to $24. It must be kept in mind that these are averages of gross and net proceeds. It is never very encouraging to consult the average of agricultural crop statistics; indeed, it is often said that "the average crop does not pay." If one should take the figures of the average crop of corn in Iowa, for instance, or the average crop of wheat in Minnesota or Kansas, and compute the proceeds at the average market price, and deduct therefrom the cost of production, the results would show a very small remuneration or an actual loss, quite discouraging to one who has not investigated this subject.

Taking what seem to be the most authentic figures, the cost of producing sugar beets in sections where they are grown by irrigation is about $40 per acre. An average of 13 tons per acre can be produced, having a higher sugar content, and worth $4.50 to $5 per ton, making the gross proceeds $58.50 to $65, and the net profit $18.50 to $25 per acre. These figures give to the farmer in each case a profit greatly more satisfactory than in the case of other crops. But the successful farmer will never be satisfied with the average proceeds of any crop, and it is to him we must look for the results that give the more encouraging

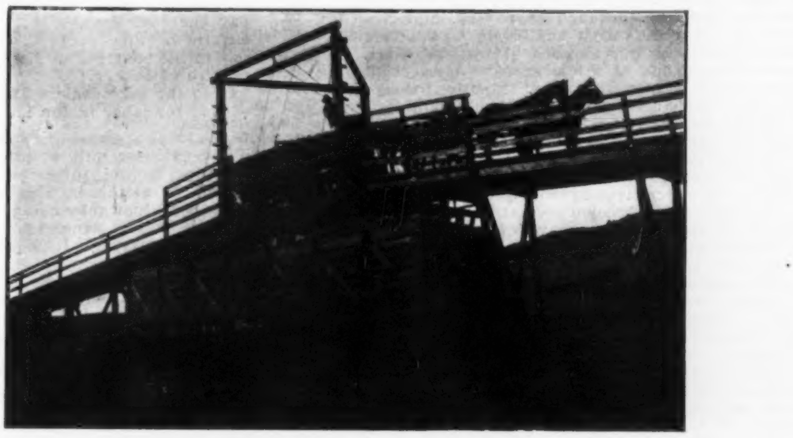


FIG. 5.—SUGAR-BEET DUMP. DANVILLE, CAL.

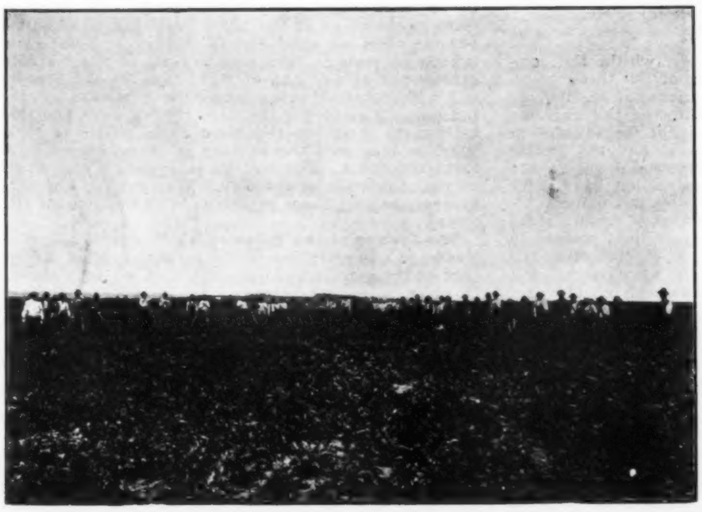


FIG. 6.—GROUP USING HOES IN SUGAR-BEET FIELDS. LEAVITT, NEB.

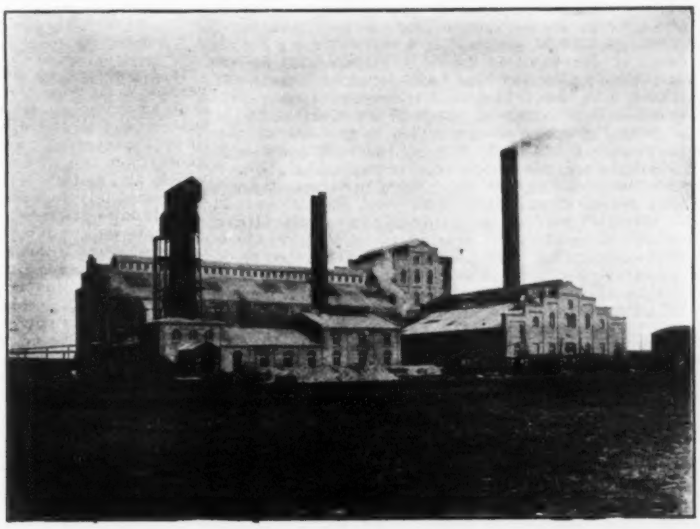


FIG. 7.—A BEET-SUGAR FACTORY. LEAVITT, NEB.

inducements to beet culture. Many growers receive as high as $75 and some as high as $100 per acre for their beets, these high results depending upon the superior quality of the land and the superior skill of the one producing the beets. If a farmer has poor land, or is a poor farmer, he is not in position to expect much in planting any kind of crop. These statements are sufficient to give a farmer who is experienced in all other kinds of crops a fair insight into the situation.

There are indirect benefits in sugar-beet growing that the farmer must take into consideration, along with the direct, as follows: He learns that sugar beets are a very valuable crop to grow for his stock. It is estimated that they are worth two-thirds as much for feeding as for the production of sugar. They may enter into a food ration for any kind of stock. The farmer growing beets for a sugar factory retains for feeding the beets that have been "docked," or that are liable to be. He constructs root cellars and stores them away, and they enter largely into all animal food rations for winter feeding. For stock feeding, sugar beets have both a nutritive and a sanitary value.

The high cultivation that must be given to the land through deep plowing, thorough harrowing, and constant weeding and cultivating finally makes the land of superior quality for any purpose. It will grow better corn or wheat, and at a less expense, on account of the absence of weeds and grass. Finally, through rotation, other fields are brought under this high state of cultivation, until the whole farm is at its best condition of soil fertility and productiveness.

The method that has brought this about serves as an object lesson to the farmer and the farming neighborhood. A better cultivation will prevail, and the science of farming will become several degrees higher on account of experience in sugar-beet cultivation.

After the beets are delivered to the factory and the sugar has been extracted, it is found that the pulp (which will amount to 50 per cent in weight of the beets worked) is almost as valuable for feeding purposes as the original beets themselves. It is a very cheap feed, and sells for 35 to 50 cents per ton. It enters naturally and profitably into the food rations of all kinds of stock. It is especially valuable for steers, lambs, brood mares, and brood sows, but reaches its highest use as animal food when fed to the dairy cow. The farmers in the neighborhood of a beet-sugar factory feed large quantities of it. They appreciate its nutritive and sanitary value. Pulp feeding gives an impetus to animal industry of all kinds. It offers a stimulus to the establishment of butter and cheese factories, to the erection of feeding pens, and to the whole stock-feeding industry. Its use is one of the strong reasons for establishing the industry.

The beet-sugar industry opens up at once a large demand for labor, not only in the factory itself but on the farm. It is one of the things in which the farmer can invest with the assurance that he has a sure market and a fixed price for his crop to begin with.

BENEFITS OF BEET-SUGAR INDUSTRY TO OTHER INDUSTRIES.

The establishment of a beet-sugar factory opens up not only a large field for the employment of labor, but also a field for the employment of capital. It becomes at once a market for considerable crude material to be used in conducting the business. First and most important it furnishes a market for the beets. Then the factory is a large consumer of coal, and as the factories are often established in communities having local coal fields, they become at once local markets for a local product. The amount of coal necessary to work up a certain amount of beets is generally computed at about 17 per cent by weight, or in case of an ordinary factory of 350 tons capacity about 60 tons of coal per day, or 6,000 tons for a full campaign of one hundred days. A factory also consumes a large amount of lime rock, which of necessity must also be a local product. It usually consumes lime rock to the extent of about 10 per cent of the crude weight of beets worked, which in the case of a 350-ton factory would be 35 tons of lime rock per day, or 3,500 tons for the campaign. It consumes about one-fifth as much coke as lime, or a little less than 700 tons during a campaign.

The establishment of a factory in a community necessitates considerable transportation of crude products—beets, coal, and lime rock—to the factory, and in carrying the finished product to the market. It stimulates banking and almost all kinds of mercantile business throughout the community.

THE FUTURE OF THE BEET-SUGAR INDUSTRY.

The following figures will give an idea of the possibilities for the expansion of the beet-sugar industry in the United States:

Consumption, Production, and Importation of Sugar.

		Tons.
For 1901 the total consumption of sugar in the United States was		2,372,000
Adding to this the average yearly increase, based on an estimate for twenty years, the consumption of sugar for 1902 will be		2,478,000
To meet annual requirements there must be imported into the United States proper this 2,478,000 tons, less what this country manufactures. The home production for 1902 should be about as follows:		
Cane sugar of the South	300,000	
Beet sugar of the North and West	185,000	
		485,000
Balance imported		1,993,000
Requirements from outside for 1902 will be in round numbers		2,000,000
Of this amount from insular possessions, free of duty, there will be received—		
From Porto Rico about	100,000	
From Hawaii about	300,000	
		400,000
There must be secured from strictly foreign sources, duty paid		1,600,000

It is the ambition of those encouraging the beet-sugar industry to establish factories enough at least to furnish this foreign importation. Making due allowance for failure of factories to reach in actual production their full capacity under ideal conditions, it would require 500 factories having a daily capacity of 500 tons of beets to produce the sugar imported, or a sufficient number of cane-sugar factories to produce an equal amount of sugar. As a matter of fact, there is likely to be a rapid increase in both beet-sugar and cane-sugar factories. But for convenience, the calculations here made are based on the supposition that the increase will be in beet-sugar factories only. In order to equip and build these factories it will require an investment of capital of $250,000,000. This vast sum of money must be expended in this country for building materials and machinery and in the employment of the labor necessary to construct and equip the factories. The annual requirements of these factories will be as follows:

Annual Requirements of 500 Beet-Sugar Factories.

They will require of beets . . . tons	18,750,000
pay farmers for the beets	$84,375,000
require of coal . . . tons	3,187,500
pay the coal dealers	$9,562,500
require of lime rock . . . tons	1,875,000
pay to the quarries for lime rock	$3,750,000
require of coke . . . tons	375,000
pay to the coke dealers for coke	$3,000,000
expend for labor in the factories	$19,000,000

In addition to the above list, large amounts of money will be paid for mill supplies, transportation, etc. As working capital to operate these factories $135,000,000 will be required. This sum being in use, however, for about four months in the year, the interest charge thereon is equal to an interest charge on $45,000,000 for one year. It should be remembered that the above estimates do not include the capital already invested in the business and the operations of the factories already built, the statement of which is as follows:

Present Development of the Beet-Sugar Industry.

Capital invested in factories, equipment, and grounds	$30,000,000
Beets purchased annually . . . tons	1,875,000
Cash paid for beets purchased annually	$8,437,500
Coal consumed annually . . . tons	318,750
Cash paid for coal annually	$956,250
Lime rock purchased annually . . . tons	187,500
Cash paid for lime rock annually	$375,000
Coke purchased annually . . . tons	37,500
Cash paid for coke annually	$300,000
Cash paid for labor annually	$1,900,000
Operating capital annually employed	$5,000,000

Also, there is a considerable amount annually expended for crude material and various other things. It hardly seems possible that an industry which affects so many people over such a wide scope of country can fail to receive anything but the most friendly, careful, and fostering consideration on the part of those who shape industrial affairs.

The immensity of future demands, it seems, answers effectually those who feel that the industry might be overdone. Attention should be called to the fact that not only are present demands great, but that the rate of increase of consumption is considerable. According to careful statistics for the last nineteen years, consumption of sugar in this country has been increasing at the average rate of about 6 1-3 per cent annually.

THE UNIVERSE AS AN ORGANISM.*

By S. NEWCOMB.

If I were called upon to convey, within the compass of a single sentence, an idea of the trend of recent astronomical and physical science, I should say that it was in the direction of showing the universe to be a connected whole. The farther we advance in knowledge, the clearer it becomes that the bodies which are scattered through the celestial spaces are not completely independent existences, but have, with their infinite diversity, many attributes in common.

In this we are going in the direction of certain ideas of the ancients which modern discovery long seemed to have contradicted. In the infancy of the race, the idea that the heavens were simply an enlarged and diversified earth, peopled by beings who could roam at pleasure from one extreme to the other, was a quite natural one. The crystalline sphere or spheres which contained all formed a combination of machinery revolving on a single plan. But all bonds of unity between the stars began to be weakened when Copernicus showed that there were no spheres, that the planets were isolated bodies, and that the stars were vastly more distant than the planets. As discovery went on and our conceptions of the universe were enlarged, it was found that the system of the fixed stars was made up of bodies so vastly distant and so completely isolated that it was difficult to conceive of them as standing in any definable relation to each other. It is true that they all emitted light, else we could not see them, and the theory of gravitation, if extended to such distances, a fact not then proved, showed that they acted on each other by their mutual gravitation. But this was all. Leaving out light and gravitation, the universe was still, in the time of Herschel, composed of bodies which, for the most part, could not stand in any known relation one to the other.

When, forty years ago, the spectroscope was applied to analyze the light coming from the stars, a field was opened not less fruitful than that which the telescope made known to Galileo. The first conclusion reached was that the sun was composed almost entirely of the same elements that existed upon the earth. Yet, as the bodies of our solar system were evidently closely related, this was not remarkable. But very soon the same conclusion was, to a limited extent, extended to the fixed stars in general. Such elements as iron, hydrogen, and calcium were found not to belong merely to our earth, but to form important constituents of the whole universe. We can conceive of no reason why, out of the infinite number of combinations which might make up a spectrum, there should not be a separate kind of matter for each combination. So far as we know, the elements might merge into each other by insensible gradations. It is, therefore, a remarkable and suggestive fact when we find that the elements which make up bodies so widely separate that we can hardly imagine them having anything in common, should be so much the same.

In recent times what we may regard as a new branch of astronomical science is being developed, showing a tendency toward unity of structure throughout the whole domain of the stars. This is what we now call the science of stellar statistics. The very conception of such a science might almost appal us by its immensity. The widest statistical field in other branches of research is that occupied by sociology. Every country has its census, in which the individual inhabitants are classified on the largest scale and the combination of these statistics for different countries may be said to include all the interest of the human race within its scope. Yet this field is necessarily confined to the surface of our planet. In the field of stellar statistics millions of stars are classified as if each taken individually were of no more weight in the scale than a single inhabitant of China in the scale of the sociologist. And yet the most insignificant of these suns may, for aught we know, have planets revolving around it, the interests of whose inhabitants cover as wide a range as ours do upon our own globe.

The statistics of the stars may be said to have commenced with Herschel's gages of the heavens, which were continued from time to time by various observers, never, however, on the largest scale. The subject was first opened out into an illimitable field of research through a paper presented by Kapteyn to the Amsterdam Academy of Sciences in 1893. The capital results of this paper were that different regions of space contain different kinds of stars and, more especially, that the stars of the Milky Way belong, in part at least, to a different class from those existing elsewhere. Stars not belonging to the Milky Way are, in large part, of a distinctly different class. Yet, the extent of each of these classes is as great as that of the universe. Throughout the whole of the extent of the latter, we find in one direction a certain class of stars to be predominant and throughout its whole circuit in other directions, a different class.

This supposition was still farther emphasized through the researches of Seeliger on the distribution of the stars in space. He exclaimed, with what we might regard as a pardonable approach to enthusiasm not common in a mathematical discussion, that the Milky Way was now to be regarded as a single object. Another curious fact is that, within it, the stars, so far as we can yet determine, seem to be equally scattered from one extreme to the other. In two opposite directions, that of the poles of the Milky Way, the number of stars which we see are fewest. Their thickness increases, slowly at first, then more rapidly, until we reach the Milky Way itself. So far as has yet been determined there is a perfect symmetry on the two sides of the Milky Way. If, on one side the stars seem to be a little thicker here than on the corresponding side, the case is the reverse in some other regions. The general rule is that if we take two diametrically opposite directions in the heavens, no matter which, and count the number of stars within a given area of, say, ten square degrees in each of these opposite directions, we shall find the number to be nearly the same. The nearer our directions come to the plane of the Milky Way, the more numerous the stars we shall find in the two opposite cases, but the increase in thickness will not be much greater at one end of our line of sight than at the opposite end. Moreover, if we change the direction of this imaginary diameter of the universe, we shall find that, so long as it makes the same angle with the Milky Way, so long will the number of stars around it remain the same. The statistical evidence also shows us that the stars of the Milky Way are, in a general average, several times as bright as those situated elsewhere.

The feature of the universe which should therefore command our attention is the arrangement of a large part of the stars which compose it in a ring, seemingly alike in all its parts, so far as general features are concerned. So far as research has yet gone, we are not able to say decisively that one region of this ring differs essentially from another. It may, therefore, be regarded as forming a structure built on a uniform plan throughout.

All scientific conclusions drawn from statistical data require a critical investigation of the basis on which they rest. If we are going, from merely counting the stars, observing their magnitudes and determining their proper motions, to draw conclusions as to the structure of the universe in space, the question may arise how we can form any estimate whatever of the possible distance of the stars, a conclusion as to which must be the very first step we take. We can hardly say that the parallaxes of more than 100 stars have been measured with any approach to certainty. The individuals of this 100 are situated at very different distances from us. We hope, by long and repeated observations, to make a fairly approximate determination of the parallaxes of all the stars whose distance is less than 20 times that of α Centauri. But how can we know anything about the distance of stars outside this sphere? What can we say against the view of Kepler that the space around our sun is very much thinner in stars than it is at a greater distance; in fact that the great mass of the stars may be situated between the surfaces of two concentrated spheres not very different in radius. May not this universe of stars be somewhat in the nature of a hollow sphere?

This objection requires very careful consideration on the part of all who draw conclusions as to the distribution of stars in space and as to the extent of the visible universe. The steps to a conclusion on the subject are briefly these: First we have a general conclusion, the basis of which I have already set

* Address before the Astronomical and Astrophysical Society of America, December 29, 1902.

forth, that, to use a loose expression, there are likenesses throughout the whole diameter of the universe. There is therefore no reason to suppose that the region in which our system is situated differs in any essential degree from any other region near the central portion. Again, spectroscopic examinations seem to show that all the stars are in motion, and that we cannot say that those in one part of the universe move more rapidly than those in another. This result is of the greatest value for our purposes, because, when we consider only the apparent motions, as ordinarily observed, these are necessarily dependent upon the distance of the star. We cannot, therefore, infer the actual speed of a star from ordinary observations until we know its distance. But the results of spectroscopic measurements of radial velocity are independent of the distance of the star.

But let us not claim too much. We can not yet say with certainty that the stars which form the agglomerations of the Milky Way have, beyond doubt, the same average motion as the stars in other regions of the universe. The difficulty is that these stars appear to us so faint individually that the investigation of their spectra is still beyond the powers of our instruments. But the extraordinary feat performed at the Lick Observatory of measuring the radial motion of 1830 Groombridge, a star quite invisible to the naked eye, may lead us to hope for a speedy solution of this question. But we need not await this result in order to reach very probable conclusions. The general outcome of researches on proper motions tends to strengthen the conclusions that the Keplerian sphere, if I may use this expression, has no very well marked existence. The laws of stellar velocity and the statistics of proper motions, while giving some color to the view that the space in which we are situated is thinner of stars than elsewhere, yet show that, as a general rule, there are no great agglomerations of stars elsewhere than in the region of the Milky Way.

With unity there is always diversity; in fact the unity of the universe on which I have been insisting consists in part of diversity. It is very curious that, among the many thousands of stars which have been spectroscopically examined, no two are known to have absolutely the same physical constitution. It is true that there are a great many resemblances. α Centauri, our nearest neighbor, if we can use such a word as "near" in speaking of its distance, has a spectrum very like that of our sun, and so has Capella. But even in these cases careful examination shows differences. These differences arise from variety in the combinations and temperature of the substances of which the star is made up. Quite likely also, elements not known on the earth may exist in the stars, but this is a point on which we cannot yet speak with certainty.

Perhaps the attribute in which the stars show the greatest variety is that of absolute luminosity. One hundred years ago it was naturally supposed that the brighter stars were the nearest to us, and this is doubtless true when we take the general average. But it was soon found that we cannot conclude that because a star is bright, therefore it is near. The most striking example of this has been brought out by the researches of Gill on the parallax of Rigel, the brightest star in Orion, and of Canopus, which is, next to Sirius, the brightest star in the heavens. In both these cases the parallax from a long series of measurements, extending through several years, came out just zero. These stars, then, though of the first magnitude, are immeasurably distant. A remarkable fact is that these conclusions coincide with that which we draw from the minuteness of the proper motions. Rigel has no motion that has certainly been shown by more than a century of observation, and it is not certain that Canopus has either. From this alone we may conclude, with a high degree of probability, that the distance of each is immeasurably great. We may say with certainty that the brightness of each is thousands of times that of the sun and with a high degree of probability, that it is hundreds of thousands of times. On the other hand, there are stars comparatively near us, of which the light is not the hundredth part that of the sun.

The universe may be a unit in two ways. One is that unity of structure to which our attention has just been directed. This might subsist forever without one body influencing another. The other form of unity leads us to view the universe as an organism. It is such by mutual action going on between its bodies. A few years ago we could hardly suppose or imagine that any other agents than gravitation and light could possibly pass through spaces so immense as those which separate the stars.

The most remarkable and hopeful characteristic of the unity of the universe is the evidence which is being gathered that there are other agencies whose exact nature is yet unknown to us, but which do pass from one heavenly body to another. The best established example of this yet obtained is afforded in the case of the sun and the earth.

The fact that the frequency of magnetic storms goes through a period of about eleven years, and is proportional to the frequency of sun spots, has been well established. The recent work of Prof. Bigelow shows the coincidence to be of remarkable exactness, the curves of the two phenomena being practically coincident so far as their general features are concerned. The conclusion is that spots on the sun and magnetic storms are due to the same cause. This cause can not be any change in the ordinary radiation of the sun, because the best records of temperature show that, to whatever variations the sun's radiation may be subjected, they do not change in the period of the sunspots. To appreciate the relation, we must recall that the researches of Hale with the spectroheliograph show that spots are not the primary phenomenon of solar activity, but are simply the outcome of processes going on constantly in the sun which result in spots only in special regions and on special occasions. It does not, therefore, necessarily follow that a spot does cause a magnetic storm. What we should conclude is that the solar activity which produces a spot also produces the magnetic storm.

When we inquire into the possible nature of these relations between solar activity and terrestrial magnetism, we find ourselves so completely in the dark that the question of what is really proved by the coincidence may arise. Perhaps the most obvious explanation of fluctuations in the earth's magnetic field to be inquired into would be based on the hypothesis that the space through which the earth is moving is in itself a varying magnetic field of vast extent. This explanation is tested by inquiring whether the fluctuations in question can be explained by supposing a disturbing force which acts substantially in the same direction all over the globe. But a very obvious test shows that this explanation is untenable. Were it the correct one, the intensity of the force in some regions of the earth would be diminished and in regions where the needle pointed in the opposite direction would be increased in exactly the same degree. But there is no relation traceable either in any of the regular fluctuations of magnetic force, or in those irregular ones which occur during a magnetic storm. If the horizontal force is increased in one part of the earth, it is very apt to show a simultaneous increase the world over, regardless of the direction in which the needle may point in various localities. It is hardly necessary to add that none of the fluctuations in terrestrial magnetism can be explained on the hypothesis that either the moon or the sun acts as a magnet. In such a case the action would be substantially in the same direction at the same moment the world over.

Such being the case, the question may arise whether the action producing a magnetic storm comes from the sun at all, and whether the fluctuations in the sun's activity, and in the earth's magnetic field may not be due to some cause external to both. All we can say in reply to this is that every effort to find such a cause has failed and that it is hardly possible to imagine any cause producing such an effect. It is true that the solar spots were, not many years ago, supposed to be due in some way to the action of the planets. But, for reasons which it would be tedious to go into at present, we may fairly regard this hypothesis as being completely disproved. There can, I conclude, be little doubt that the eleven-year cycle of change in the solar spots is due to a cycle going on in the sun itself. Such being the case, the corresponding change in the earth's magnetism must be due to the same cause.

We may, therefore, regard it as a fact sufficiently established to merit further investigation that there does emanate from the sun, in an irregular way, some agency adequate to produce a measurable effect on the magnetic needle. We must regard it as a singular fact that no observations yet made give us the slightest indication as to what this emanation is. The possibility of defining it is suggested by the discovery within the past few years, that under certain conditions, heated matter sends forth entities known as Röntgen rays, Becquerel corpuscles and electrons. I can not speak authoritatively on this subject, but, so far as I am aware, no direct evidence has yet been gathered showing that any of these entities reach us from the sun. We must regard the search for the unknown agency so fully proved as among the most important tasks of the astronomical physicist of the present time. From what we know of the history of scientific discovery, it seems highly probable that, in the course of his search, he will, before he finds the object he is aiming at, discover many other things of equal or greater importance of which he had, at the outset, no conception.

In his study of what is going on among the stars, even the astronomer may for a time fail to grasp the true significance of what he sees through leaving out of account the vastness of the field which he is surveying. A remarkable case of this is seen in the case of the new stars which have been known to burst forth from time to time. In at least two notable cases of this kind within the past ten years, such stars have been found, within a few months after their outburst, to be changed into or surrounded by a nebula. Nothing could, at first sight, seem more natural or easily explained than this occurrence. To whatever cause we may attribute such a catastrophe as the sudden multiplication, within the period of two or three days, of the light of a sun by thousands of times, the cataclysm must result in throwing out a mass of incandescent vapor, rising with great speed. This vapor expanding on all sides, will appear to us as a nebula surrounding the star and continually enlarging. That any difficulty can stand in the way of this view will first appear when we make an estimate of the probable extent of such a nebula. To do this requires that we know something of the distance of the star. This can not be determined by any absolute method, so that our conclusions as to the distance must in part be conjectural. Yet we can say with a high degree of probability that the annual parallax of these new stars can scarcely be much greater than the thousandth of a second. We have two independent bases for this conclusion.

One is that such stars have never blazed forth except in the regions of the Milky Way. We are therefore justified in believing them as distant as the Milky Way. Now one of the results of stellar statistics which we need not stop to reason out at the present time is that the distance of the Milky Way can scarcely be much less than that corresponding to the parallax I have indicated. Even this distance falls far short of the estimates of Sir William Herschel, who is stated to have placed the outermost visible stars of our system at a distance which light would require many thousand years to traverse. He supposed us to see all the stars of the Milky Way by pre-Adamite light. But the distance which I have indicated is that over which light would travel in about 3,400 years.

The other argument on the subject may be briefly stated in this form. From what we know of the thickness of the stars in our immediate neighborhood, there is every reason to believe that, out of several hundreds of millions of stars in the universe, not more than twenty thousand are within the distance corresponding to a parallax of 0.02". The chances are, therefore, more than ten thousand to one that any star in the universe, taken at random, would lie within this range of distance from us.

Another reason for placing the Milky Way, and with it the new stars, at this distance is found in the absence of proper motions from such stars. Most careful and refined measures made by Barnard on Nova Persei show a motion of only 0.01" in the course of a year, which is only saying that no motion has been seen. Although this result is not conclusive, it affords additional very strong evidence in favor of the view that this star was really in the region of the Milky Way.

Assuming, then, that the distance is of this order of magnitude, let us ask at what speed a nebula must rise in order that it may expand as rapidly as observation seems to show the matter around Nova Persei to have flown outward. Calculations would show this speed to beggar all our conceptions. The highest speed which matter has been known to reach is that attained by the eruption of hydrogen and other gases from the sun, which sometimes amounts to several hundred miles a second. But matter moving only with such a speed as this would require centuries to form a nebula of appreciable size at the distance we have assigned to the new stars.

The application of this principle to the case of Nova Persei led to an ingenious suggestion by Kapteyn that the seemingly slow expansion of the nebula which surrounds Nova Persei was not a motion of matter at all, but only an illumination of nebulous matter already existing by the wave of light thrown out from the exploded star. At first sight the reply to this suggestion might be that the observed expansion cannot come up to light in speed. One might be astonished to hear that, inconceivably swift as is the motion of light, it might well be that, at such a distance, it would seem to us as slow as the apparent expansion of the nebula in question. But when we put the matter into cold figures, we find that the great difficulty in the way of accepting Kapteyn's explanation is the opposite of this. What we have to deal with is not the apparent slowness of the motion, but the inadequacy of the speed of light to explain the phenomena. If the distance of this star is only 400 times that of α Centauri, the speed of the apparent expansion must have been ten times that of light.

Of all agencies known to be propagated through space in time, light is the swiftest in its motion. We may, therefore, say that no known cause coming into action in February, 1901, could, within the twenty-two months which have since elapsed, have emanated from the star so as to make itself felt outside of a sphere which, at the distance in question, would subtend to our eyes an angle of more than four minutes in diameter. We seem, therefore, forced to the conclusion that either the illumination or nebulosity surrounding Nova Persei during the summer of 1902 existed independently of the outburst of the star, or there exists in the universe a cause susceptible of transmission with a speed several times that of light.

When we look closely into the matter, we find some difficulty in proposing any hypothesis based on the known action of natural agents. A continual course of self-discipline is necessary to enable us to appreciate the real significance of the question. The facts, as I understand them, are briefly these: We see by photography an object in the heavens in which certain changes are going on consisting of variations in the appearance of the illuminated portions. Day after day we see that a certain illumination beginning at a point, *A*, no matter where, spreads to a point, *B*, and perhaps a point of light, *C*, begins to show itself. The natural conclusion is that something is being propagated. The point, *B*, has received an emanation from *A* and the point *C* has not appeared spontaneously, but has been connected with something going on at some other point, perhaps the central star. In attributing this propagation to that of anything but light and radiant heat, we are met by the difficulty that all other known natural causes which could have operated in such a case fall short of this in their speed of transmission.

Whichever way we turn we meet with difficulties which seem insuperable in constructing any theory that will explain the observed phenomena. The light theory which I have mentioned is rendered more unlikely from the fact that the latest researches upon the Lick photographs seem to show that the emanation did not go out in straight lines with uniform velocity, but branched off here and there, sometimes in one direction and sometimes in another, with varying speed. There is a difficulty in attributing the apparent expansion to the motion of light which seems yet greater than this. The speed of light is perfectly uniform. The outburst was extremely sudden, it being only two or three days from the time when the star became visible until it reached first magnitude. Under the circumstances the outgoing light-wave would have been a well-defined spherical surface, brightest at a point so near the actual surface that its extent would not be visible at such a distance. The star faded away at a rate which reduced it to one half in a very few days and again to one half in a few days more. The light emanating from such an object would, therefore, have presented to our eyes the appearance of a well-defined luminous circular disk, brightest at the circumference, outside of which all would have remained in complete darkness. It is true that, owing to the difference of density of the material reflecting the light, the disk would not have been uniform. It might have many gaps here and there and present a cloudy appearance. But with all these differences the boundary would have been as well defined as if the disk had been turned in a lathe.

This would suggest our having recourse to the corpuscles of which the investigation is now beginning and may be the main subject of physical research during the next generation. But here, if we accept the theoretical result of Prof. J. J. Thomson, we meet with the difficulty that these entities can not travel with a greater speed than that of light. Under these circumstances nothing seems left for us in the present state of our knowledge but to turn over to our successors the problem of explaining the phenomena.

The main point I desire to bring out in this review is the tendency which it shows toward unification in physical research. Heretofore differentiation—the subdivision of workers into a continually increasing number of groups of specialists—has been the rule. Now we see a coming together of what, at first sight,

seem the most widely separated spheres of activity. What two branches could be more widely separated than that of stellar statistics, embracing the whole universe within its scope, and the study of these newly-discovered emanations, the product of our laboratories, which seem to show the existence of corpuscles smaller than the atoms of matter? And yet, the phenomena which we have reviewed, especially the relation of terrestrial magnetism to the solar activity, and the formation of nebulous masses around the new stars, can be accounted for only by emanations or forms of force, having probably some similarity with the corpuscles, electrons and rays which we are now producing in our laboratories. The nineteenth century, in passing away, points with pride to what it has done. It has became a word to symbolize what is most imporant in human progress. Yet, perhaps its greatest glory may prove to be that the last thing it did was to lay a foundation for the physical science of the twentieth century. What shall be discovered in the new fields is, at present, as far without our ken as were the modern developments of electricity without the ken of the investigators of one hundred years ago. We can not guarantee any special discovery. What lies before us is an illimitable field, the existence of which was scarcely suspected ten years ago, the exploration of which may well absorb the activities of our physical laboratories, and of the great mass of our astronomical observers and investigators for as many generations as were required to bring electrical science to its present state. We of the older generation can not hope to see more than the beginning of this development, and can only tender our best wishes and most hearty congratulations to the younger school whose function it will be to explore the limitless field now before it.

THE CROCODILE IN ANCIENT EGYPT.

ACCORDING to the authors of ancient times, the Nile conceals in its rapid waters two species of crocodiles, one of which sometimes attains gigantic proportions, while the other never reaches a large size. Such testimony is confirmed by modern naturalists, who have described the large species under the name of "champse" and the small one under that of "suchus." The body of the former is elongated like that of the lizards, the head is oblong, and the snout depressed,

FIG. 1.—HORUS, THE CONQUEROR OF THE CROCODILE.

while the tail, instead of appearing to be a continuation of the back, is, from birth, beneath the level of the latter and clearly distinguished from the trunk—a peculiarity that the Egyptians always observed, although somewhat exaggerated.

This reptile, which upon making its exit from the egg measures scarcely 8 inches, sometimes reaches a length of 33 feet. Its general color is a somewhat dark green bronze, set off here and there with a few black blotches. Essentially a carnivore, and very ferocious when pressed by hunger, it attacks animals of large size, such as oxen, asses, horses, etc., while man himself is often its prey. But, although the crocodile exhibits great boldness in water, its favorite element, it is more timid upon land, and scarcely ever ventures very far from the river. All birds and all beasts give it a wide berth. The Egyptian "trochilus" alone lives in peace with it, since feeding upon the insects that encumber the mouth of the reptile, the latter experiences a great relief from being rid of them, and so does the bird no harm. This horrible monster was designated by the Egyptians as the "emsahu," whence are derived the Greek name "champse" and the Arabic "timsah." It is the "leviathan" of the Bible.

The "suchus" differs from the "champse" in its head being more flattened and more pointed, its body less thickset, and its tail up to the extremity appearing to be a prolongation of the body. It is distinguished also by its length, which hardly reaches nine feet. The texts name it "souk," a word that has been changed into "suchus." These dangerous amphibians have now disappeared from Egypt. It is only at Wadi-Halja that traces of them have begun to be found. In ancient times, their number was so great that, in the fourth century before our era, they made way with more than a thousand soldiers of the army of Perdiccas while he was leading it across the Nile opposite Memphis, in order to march against Ptolemy Lagus. According to Herodotus, some of the Egyptians considered the crocodile as sacred, while others waged a bloody war against it. The people who adored the animal lived in territories extending far from the Nile, in the interior of the country—a situation that put them under cover from the attacks of the terrible carnivore. It was only at the period of the inundation, always expected with impatience, that the inhabitants of such districts witnessed the arrival of a multitude of crocodiles, which, swept along by the waters, were distributed with the latter over the land dried by the sun. So they had a very great veneration for an animal, the sight of which was the prelude to an era of prosperity. In the Arsinoëte province, which, by reason of its distance from the

FIG. 2.—THE GOD SEBEK.

Nile, would have been uninhabitable without the derivations from inundations of this river, the return of the fecundating waters and that of the animal intimately connected with this phenomenon was hailed with still greater enthusiasm than in the rest of Egypt. So, the Arsinoites, holding the crocodile in great honor, made it the tutelary god of their city, and, at the Roman epoch, struck medals bearing its effigy. Acording to Herodotus and Strabo, they were fed in Lake Moeris upon the flesh of victims and other prescribed food. The animals were tamed by the priests and called "suchos." In their ears shone

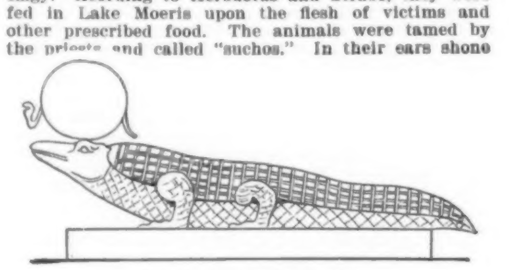


FIG. 3.—THE SUCHUS.

rings of gold, and their fore feet were ornamented with bracelets. When strangers came bearing viands and cakes, the priests who were appointed to guard the monsters opened their jaws and put in their mouths the delicacies that were intended for them. Objects of careful attention during their life, they were, after death, embalmed and deposited in the crypts of the labyrinth. At Ombos, which likewise was situated far from the Nile,* upon the Arabic side, crocodiles were also greatly venerated. The Ombites kept them in large reservoirs excavated in the rock. When these animals seized young children, the mothers of the latter exhibited great joy, considering it the height of happiness to have brought into the world something to serve as food for their god. Coptos and two other cities of the name of Crocodilopolis rendered a like homage to this formidable saurian. At its death, it was embalmed in the same manner as at Arsinoë and deposited in a place set apart for its sepulture. In our own day a necropolis of the sacred crocodiles may still be seen at Maabda, upon the right bank of the Nile, opposite Manfalout. It is a maze of subterranean galleries in which, mingled with human bones and the remains of birds and quadrupeds, lie thousands of mummies of crocodiles of all kinds and dimensions.

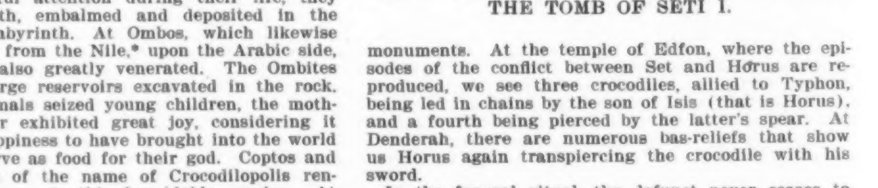


FIG. 4.—THE CHAMPSE.

At the epoch at which the Greeks visited Egypt, this cult rendered to a cruel reptile was explained by the most fantastic stories. Some of the Egyptians attributed it to the faculty that the crocodile possesses of predicting the future. They stated that one of the Ptolemies one day presented his offering to a sacred crocodile, which refused to receive it, because it knew of the approaching end of this prince, who, in fact, died a short time afterward. The reason furnished by Eusebius appears to be the most probable. He tells us that the Egyptians, in adoring the crocodile, intended to recognize the benefits due to the inundations, of which this animal was always the precursor—an idea that they expressed by crocodiles towing a bark in the irrigation canals. The same was not the case with the population living on the banks of the river, which, constantly exposed to the attacks of the reptile, stood in great dread of it. An endeavor was made to conjure it by magic formulas, such as: "Come to me, O lord of the gods! Ward off from me the crocodiles coming from the river!"

Treated as an enemy, it was hounded to death, and no scruples were made about eating it. A bas-relief of the ancient empire shows us individuals sailing in a canoe and hunting it with strong spears. Another method, less dangerous, consisted in capturing it by means of a hook baited with pork. In Apollinopolis, where there was a law that compelled every citizen to eat crocodile meat, the animal was taken in nets suspended from laurel trees. There, after a few lamentations, it was scourged, cut into pieces and greedily eaten. Full of animosity for this reptile, which, in feeding upon human beings, deprived them of burial, the Tentyrites alone dared to attack it squarely, and forced it to give up the body that it had stolen. Such contrary feelings as these shown in regard to the same animal by contiguous populations, often led to numerous altercations, which sometimes resulted in bloody battles. The quarrels of the inhabitants of Coptos, adorers of the crocodile, with those of Tentyris, its mortal enemies, are described by Juvenal, who tells how the latter, in the wake of a festival, ate alive an unfortunate Coptite, who in his precipitate flight had slipped in blood and fallen in the midst of them. Set-Typhon, the god of evil, in order to escape Horus, assumed the form of a crocodile, which personified the burning heart of the sun, the rays of which dried up the land and caused sterility. The Egyptians made of it an emblem of destruction and darkness. It was consecrated to Sebak, one of the forms of Typhon. It is generally with a Typhonian character that this reptile is revealed to us in the

FIG. 5.—CONSTELLATION IN THE ZODIAC OF THE TOMB OF SETI I.

monuments. At the temple of Edfon, where the episodes of the conflict between Set and Horus are reproduced, we see three crocodiles, allied to Typhon, being led in chains by the son of Isis (that is Horus), and a fourth being pierced by the latter's spear. At Denderah, there are numerous bas-reliefs that show us Horus again transpiercing the crocodile with his sword.

In the funeral ritual, the defunct never ceases to invoke the protection of the gods against the crocodile: "Put me in possession of your magic charms," exclaims he, "save me from the crocodile of this land of truth!" As an emblem of the infernal abode, the reptile is, along with other Typhonian animals, placed at the entrance of the syringes of the royal tombs. In the Zodiacs, we frequently see it associated with the hippopotamus. Nevertheless, the crocodile does not always evoke a pernicious idea, but, in certain cases, appears rather with a beneficent character. The symbolical composition of the island of Philæ represents a crocodile playing a role analogous to that of the cow Hathor. Like the divine heifer, it is carrying a mummy upon its back toward the funeral mountain. At the tomb of Seti I., the crocodile Abou-Sahou is the guardian of the image of Osiris and the

* Ombos at present is on the bank of the Nile, which flows over the site of an old irrigation canal. We still find traces of the ancient river bed at a great distance toward the west.

protector of pure souls that are informed as to the secrets of the other world. We find even the word "Sebek" in the composition of certain proper names of the middle empire. Such are those of the Pharaohs Sebek-Emsaouf and Sebek-Hotep. A princess, a sister of Amenemha IV., was called Sebek-Neferou-ra. According to Horapollo, the eyes of the crocodile represented the aurora, because, in rising from the depths, they emerge above the waves before any other part of the body. Wishing to show how great a veneration they had for the crocodile, the Ombites rendered it homage in the same temple in which they did homage to Horus. This temple was divided widthwise into two equal parts. On the left, stood the tabernacle of Sebek, the gloomy god of evil, emblem of darkness, and, on the right, that of resplendent

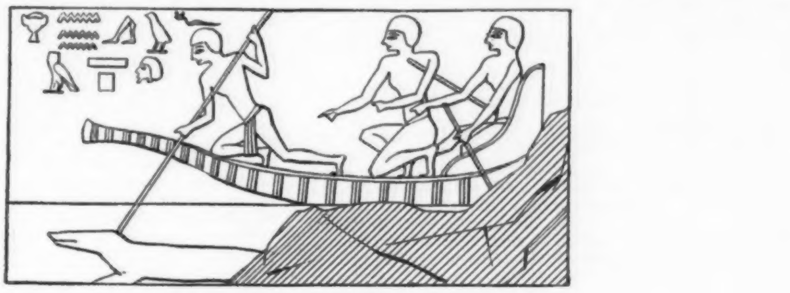


FIG. 6.—HUNTING THE CROCODILE; FROM A BAS-RELIEF OF THE ANCIENT EMPIRE.

Horus, the beneficent divinity, whence emanates only light and beauty. In the hymn to the Nile, the crocodile is celebrated in lyric terms:

All hearts are full of joy!
The children of Sebek, the sons of Neit,
The divine cycle, which resides in thee, prosper!

The Egyptian artists depicted this reptile very well. The "champses" sculptured at Khom-Ombos are remarkably true to life. However, aside from a few amulets, they do not seem to have made a wide application of it in either monumental or industrial art. At Rome, the crocodile does not appear for the first time until 58 years before Christ. Scaurus showed five specimens of it to the people on the occasion of assuming the edileship. Some years later on, Augustus, after he had triumphed over Cleopatra, brought home a large number of the reptiles, which he made fight in the plays of the circus. Heliogabalus reared some of the animals.

This saurian so well characterized Egypt that the Hebrew poets employed the same expression, "rahab," to designate the crocodile and its country. When Egyptian soldiers were established at Nimes in the time of Augustus, this city engraved upon its medals, and always preserved in its armories, a crocodile attached to a palm-branch, as a symbol of its colonial origin.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from the French of P. Hyppolyte Boussac in La Nature.

THE TEREDO.

A MENACE to every wharf from the Black Sea to Christiania, this extremely destructive mollusk, the ship worm, causes to-day enough expenditure to pay for a navy. Its steady burrowings were within an ace of causing the inundation of a large part of Holland. Along the sea wall had been built a system of dykes, made principally of timber. In three years breaks were being patched up, in five whole sections gave way. Only the heroic efforts of the whole seaside population saved the Dutch from one of the worst catastrophes in their history. The timbers were completely honeycombed, so rotten that the wood could be crushed in the hand.

The one good deed this pest has done for England was to suggest to Sir S. Brunel his plan for the Thames tunnel. This, however, will hardly balance the damage. Yarmouth must rebuild its piers every three years. Wooden vessels have to be scraped and painted every four or five months.

North America suffers as much as Europe. All down the New England coast piles are attacked and destroyed. In this region two years forms the average life of a piece of submerged timber. Channel buoys are left in the water only six months in the year, then a new set is put in and the old one dried. Even in the brackish water of New Haven harbor, ship bottoms and wharf supports are attacked.

The zone of the ship worm's devastation is comparatively large. Wood is attacked between points well above low water mark and points ten or more feet below it. To these animals the hardest oak offers no more difficulties than the softest pine. If necessary they can bore their way through the toughest knots. Teak alone resists their attacks.

The cause of this vast amount of damage, the *Teredo navalis*, much resembles the common worm from which comes its usual name. It is a true mollusk of the order of bivalves. Its long, whitish body, tapering toward the posterior end, is found imbedded in a shell-lined burrow. Individuals of this species sometimes attain the length of ten inches, are one-quarter inch in diameter. Such size, however, is rare, four inches being about the average length.

The "head" end of the animal is covered with a helmet—a white bivalve shell like that pertaining to the clam. That this is not used in boring the hole is proved by the fact that the shell is covered by a very thin and delicate epidermis. The boring is probably done by a broad, muscular organ slightly rounded at the tip—the foot. Together with the mouth, liver and palpi, it is situated beneath the bivalve shell. The gills (feathery organs of a light brown color), and likewise the digestive organs, are in the soft part of the animal. Two pallets, shaped and fastened to the posterior end of the body, much as leaves are fastened to the stem, close the teredo's hole, and protect from attacks the soft portions of the animal. Between these two plates lie the siphon tubes—used for inhaling and exhaling water. Through the lower of these (branchial) is drawn the water breathed by the animal, and likewise those minute animalcules which serve it for food. The dorsal tube serves as the organ of excretion. Through it passes a stream of vitiated water carrying along the fæces and the wood excavated. Surrounding both the pallets and the siphon tubes is a much wrinkled muscular band, by which the teredo adheres to its "burrow."

The appearance of the teredo burrow is very peculiar. Outwardly the piece of timber infested shows a number of very small holes. Inwardly it resembles nothing more than a Swiss cheese. The channels run in all directions sometimes so close to each other that the wood separating them is as thin as paper. But between the holes there is always a partition, for the animals never interfere with each other. Their sense of hearing seems to enable them to tell when they are approaching the outside of the wood or are nearing another burrow and they turn aside. The holes are always lined with irregularly laid shell and they generally go with the grain. Like many other mollusca the teredo passes through a long series of complicated metamorphoses before arriving at full maturity. The eggs, from the beginning of the breeding season in May, are confined in the gill cavity. Here they have their first period of growth. From the gill cavity the embryos are discharged in the form of free swimming animals covered with vibrating cilia or hairs, by which they swim. In this stage they are almost exactly like ciliated infusoria. Next they lose these locomotive filaments and develop a rudimentary bivalve shell. In the third stage their relation to other bivalves is apparent in their resemblance to the common mussel. They have a mantle and shell covering their entire body and another sort of cilia replaces those lost. This bivalve character is further accentuated by the development of a long foot used for creeping and by the appearance of eyes and organs for hearing. These eyes, however, disappear as the animal elongates and the locomotive cilia are lost. In this stage the young teredo, settling on some convenient piece of wood and starting with a hole about the size of a pin-head, begins his burrow.

One season suffices to mature the ship worm. Beginning with a very small hole it grows and enlarges the orfice as it goes in. Since it is able from its sense of hearing to touch or avoid the holes of other teredos, its tunnels are often crooked, even tortuous. But when the animal is brought quite to a standstill, by not being able to advance the burrow further, it enlarges the ends of its holes. Then the openings to the outside are hermetically closed, and in its self-made grave the teredo curls up and dies.

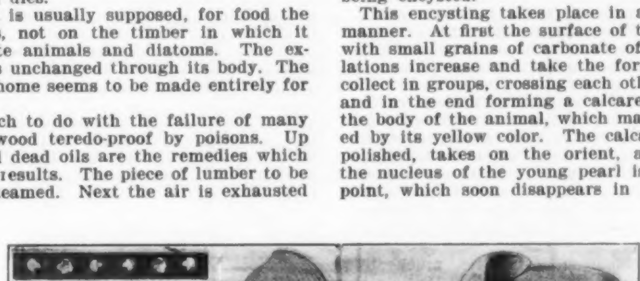
Contrary to what is usually supposed, for food the ship worm depends, not on the timber in which it lives, but on minute animals and diatoms. The excavated wood passes unchanged through its body. The hole that forms its home seems to be made entirely for protection.

This fact has much to do with the failure of many attempts to make wood teredo-proof by poisons. Up to date creosote and dead oils are the remedies which have given the best results. The piece of lumber to be so treated is first steamed. Next the air is exhausted and the poisonous or noxious compound is forced in under a pressure of four hundred pounds to the square inch. Usually, however, this system fails of the desired result. At Christiania, timbers poisoned in this manner were found to be, three years later, quite riddled with teredo. In some instances, however, piles so treated have been known to remain free from ship worms for as many as fifteen to twenty years.

Although poisoned timbers are often used for such structures as government docks (which must be as permanent as possible), for ordinary piers and for submerged work, the expense of so treating the wood is generally greater than the cost of periodically laying new shafts, which, in this New England locality, can be driven at about $1.50 per pile. The cost of the treated pile is so much greater than this, that with the added element of uncertainty, poisoning the wood is, for practical purposes, hardly worth while.

Since thorough drying or periodic exposure to fresh water will kill the teredo, if the woodwork is of such a kind that either of these methods is applicable, it is generally applied. Our coasting vessels keep themselves free from "worms" by lying to in fresh water while loading and unloading. All along this coast two sets of buoys are kept, and those which have lain in the water for a year are changed for others in June or July. The alternate set is dried out and serves the next year. In this manner buoys which, if left in the water three years, would probably see the end of their service, are made to last for twenty. Of course, the most thorough defense would be one which prevented the entrance of the young animal. Copper-sheathed vessels are quite free from its attacks, while copper paint, creosote or coal tar frequently applied has the same effect. Piles may be defended by broad-headed nails closely driven, for the ship worm seems to avoid entering any wood impregnated with iron rust.

That the cheapest way in which wooden piers and docks can be maintained is by rebuilding them every few years, is a remarkable commentary on the injury wrought by the teredo. Any improvement on the present clumsy and expensive method of protection will be a very genuine benefaction. —Yale Scientific Monthly.



THE TEREDO—A MENACE TO SHIPS AND SUBMARINE CABLES.

ORIGIN OF PEARLS.

THE savants of the Académie des Sciences have taken up the question of the formation of pearls, stimulated by the investigations of M. Raphael Dubois. If they can succeed in producing pearls by chemical methods, as M. Moissan has produced veritable diamonds, the discussion will not be in vain; but their jewels must be of more liberal dimensions than Moissan's diamonds. In any case, the discussion is likely to throw some additional light on the treatment and preservation of pearls. M. Dubois is continuing his researches.

The following are translations specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT of the papers that have so far appeared:

FORMATION OF PEARLS IN THE MYTILUS EDULIS.

From the French of M. Raphael Dubois. Paper presented to the Académie des Sciences.

Notwithstanding the researches of a large number of investigators, we still encounter the most diverse and contradictory hypotheses on the origin and mode of formation of real pearls, that is those found in the soft parts of the pearl mollusks.

The facts which I have observed, and which have been set forth in a communication to the Congress of the French Association for the Advancement of Science at Ajaccio leave no doubt as to the origin of the true pearls found in such abundance in edible mussels, which by them are rendered unsuitable for consumption. If the mussels which, at certain points on the shores of the ocean, are usually filled with pearls, are examined in the month of August (as I have done), surprise may be felt that pearls are no longer met with, or only in rare cases, or merely in the form of calcareous debris, which I cannot compare better than with the fragments of carious teeth. Among the pearls still found are very small ones newly formed and old ones which have preserved their orient, but most of these have taken on a milky appearance, a dead white, betokening the commencement of disaggregation.

But if few pearls are noticed at first, numerous small pearls of reddish yellow will be discovered, on considering attentively the mantle of the animal. These are produced by minute young distoms from four to six tenths of a millimeter in size, in process of being encysted.

This encysting takes place in an extremely curious manner. At first the surface of the distom is covered with small grains of carbonate of lime. These granulations increase and take the form of crystals, which collect in groups, crossing each other in different ways, and in the end forming a calcareous envelope around the body of the animal, which may yet be distinguished by its yellow color. The calcareous shell becomes polished, takes on the orient, and at this moment the nucleus of the young pearl is only a small black point, which soon disappears in its turn. The pearl now has a fine orient, and continues to grow by its periphery, in contact with the membranous pocket surrounding the calcareous cyst. The parasite can be made to reappear by decalcifying the young pearls by means of chlorhydric acid. There can, therefore, be no doubt as to the nature of the nucleus. According to my observations, the *Distomum margaritarum* becomes encysted in the *Mytilus edulis* on the coasts of the ocean about the middle of August and remains encysted until the following summer. At the commencement of this season the calcareous shell loses its polish and becomes disaggregated, as is proved by the fragments of which I have spoken. At a given moment, there can only remain a gelatinous mass corresponding without doubt, to the gelatinous pearls noticed by M. Diguet in the *Meleagrin margaritifera*. The

parasites then resume their active life, are reproduced, and the young distoms are encysted anew and form pearls.

There are pearls which escape the physiological formation and may attain greater size because the distom is dead, killed by another parasite (perhaps a sporozoan), or because it is a sterile being at the end of a line. The most beautiful pearl is therefore in reality only the brilliant sarcophagus of a worm.

In 1830 a German naturalist, Von Baer, expressed the opinion that free pearls had for a central nucleus a small animalcule or worm. In 1852 De Filippi of Turin affirmed that the pearls of the *Anodonta cygnea* of the Lake of Racconigi had for a nucleus a worm, specifically a distom (*Distomum duplicatum*). Through the courtesy of the King and Queen of Italy, who have been pleased to second my efforts, and the valuable co-operation of my eminent colleague, Prof. Paghani, Dean of the Turin Faculty of Medicine, and of my learned confrère, Dr. Quirico, the king's physician, I have been able to procure from the lake of the royal castle at Racconigi materials which will allow of deciding whether the pearls of the Anodentes, fresh water mollusks, are like those of the marine Mytilus the work of a distom.

The Origin and Mode of Formation of Small Pearls.

Paper of M. L. G. Seuret.

In a recent communication M. Raphael Dubois has made known the mechanism of the formation of small pearls in the *Mytilus edulis*. It may be useful to call attention to some important investigations which seem to have escaped the attention of this savant.

1. The mechanism of the formation of pearls in the comestible mussel was studied by Garner, and the results published by him are nearly identical with those reached by M. Dubois thirty years later. Garner considers that they are due to the existence in the shell-secreting mantle of the animal of minute parasitical entozoa, against which the natural protection which the mollusks have is a calcifying process around the parasites; and as after this they still act as foreign bodies, a continuation of the same process leads to the formation of pearls, and that it is reasonable to conclude that oriental pearls are formed in an analogous way.

The theory of the parasitical origin of pearls was put forth in 1852 by the Italian naturalist De Filippi, who attributed the frequency of pearls in the Anodantes of the royal park of Racconigi to the presence in the mantle of these mollusks of a tremitode parasite.

On the contrary, Kuchenmeister in 1856 expressed the opinion that the formation of these pearls was due to an acarion parasite.

Parasitical worms may also in certain cases determine the formation of pearls in the pearl oyster. Mobias noticed this fact in the pearls of the western coast of America. In 1859 Kelaart and Humbert concluded that the cercaria, filaria, and three other helminths, found by them in the viscera of the pearl oyster of Ceylon, acted an important part in the formation of the pearls of this mollusk. More recently, 1894, M. Edgar Thurston confirmed the views of Kelaart.

In 1897, M. A. Giard noticed the production by the mollusk around the parasite of irregular deposits of conchiolin and lime, sometimes even of small pearls.

2. The researches of Von Baer related to the Mulettes and the Anodons. He found in the mantle and skin of these mollusks small isolated coagulated masses, which he examined frequently. But he was unable to discover in them any evidence of an organized being. Von Baer was persuaded that the pearls are the result of the ulterior calcification of these masses or isolated concretions. He considered these concretions as pathological productions, whose origin had not been observed with certainty.

Recent researches cannot be considered as having reached a definite and general solution of the problem.

Formation and Maladies of Pearls.

Paper of M. S. Jourdain.

Pearls are concretions formed of carbonate and phosphate of lime, associated with a small quantity of animal matter. They are produced by various acephalous mollusks. They consist of very thin layers of mineral matter, arranged in such a way as to give rise to the phenomena of interference, producing that brilliancy and orient which have made them sought for in all ages as objects of adornment.

Their origin and formation have been much discussed. Without recounting all the poetical legends to which they have given existence, naturalists seem to infer that they may be formed in any part of the mollusk. This notion is erroneous.

All pearls are formed by the mantle, and it is only afterward and by accident that they are found in other parts. The examinations of the *Unio* leave no doubt in this respect.

The identical chemical composition of the internal nacreous layer of the valves of the mollusk and of the pearls corroborates this view.

The walls of a bivalve shell are composed of two layers, each having a special origin. 1. An epidermic layer, produced on the border of the mantle, and forming its organic continuation. 2. An internal layer, composed of very thin lamellæ, secreted by the external surface of the pallial envelope.

The first of these layers increases the periphery of the valves; the second augments their thickness.

It is in consequence of a lesion, or the presence of a foreign body, organic or inorganic, that a depression is produced in the pallial surface, with a hypersecretion of nacreous matter, forming concentric layers around the foreign body as a nucleus. The concretion, thus formed, usually remains at first adherent to the pearly layer of the corresponding valve and separates from it later, becoming free. This action of the pallial surface explains the process employed by the Chinese for the production of small nacreous bas-reliefs. It is sufficient to introduce the surface to be pearled between the mantle and the internal face of the shell, making the reverse of the relief adhere to it in some way.

Pearls can ordinarily be preserved for long periods without change. However, they may become *sick*, that is, undergo various modifications, causing them to lose the qualities on which their value depends.

These maladies are spontaneous or acquired. The first consists of a sort of disaggregation of the superficial layers produced slowly, and in the end destroying the brilliancy and orient of the pearl. It is possible to remedy the evil, at least for a time, by the removal of the affected layers, either by a chemical process or by mechanical polishing.

The acquired maladies are produced by prolonged or repeated contact with the skin, whose acid secretions and sebaceous matter exert a deleterious influence. They may also occur from the influence of gaseous emanations, sulphydric acid in particular. Pearls in time acquire a slight amber tint, which is far from diminishing their value; but when this tendency exceeds a certain limit, they become blackish, the organic matter being modified by the causes that have been mentioned. I know of no remedy then for the sick pearl, and believe that its depreciation is inevitable.

THE OIL-PALM OF WEST AFRICA.

The extraction of palm-oil and palm-kernels, the two principal products of the oil-palm (Elæis guineensis), is one of the most important industries on the West Coast of Africa, the trade in these two articles at the present time being estimated at about £2,500,000 per annum. Curiously enough, the preparation of the oil has never been attempted in factories under the supervision of Europeans, but has remained altogether a native industry, so that the methods of extraction are tedious and wasteful. Dr. Preuss, the director of the Victorian Botanical Gardens, gives an account, in a recent number of Der Tropenpflanzer, of some experiments he has made in the Cameroons on this subject, and makes several suggestions which, if they could be adopted, would greatly economize the present cost of production. The fruit from which the oil is made consists of an outer coating of tough pulp, and an inner hard shell inclosing the kernel. The pulp which contains the palm oil is, by the native method, first softened by boiling for two hours in water, and then beaten from the hard inside shell with wooden pestles, forming a fibrous, oily mass, from which the crude oil is pressed out by hand. This raw product is then refined by melting it in hot water and skimming off the oil as it floats to the surface. It is obvious that the fibrous residue of pulp must, under these conditions, retain much oil, and in one experiment, made under Dr. Preuss' directions, only about 33 per cent of the available oil was obtained. Usually, however, better results were secured, since analyses of the fibrous residue made in Europe show a content of oil varying from 12 to 20 per cent. The author gives in the original paper impressive figures showing the enormous losses which this failure to extract the whole, or at least the greater part, of the available oil means to West Africa in general and the Cameroons and Togoland in particular. At the present time there is no way of avoiding this loss, but he points out that it should be possible to devise a cutting machine which would separate the pulp from the nut, when the former could be readily worked up in some form of hot oil press. A machine for this work would, however, have to be capable of readily adjusting itself to deal with fruits of various sizes.

From the mass of pulp referred to in the foregoing paragraph the nuts are picked out by hand, and laid aside to be worked up for the contained kernels, the latter being usually obtained by breaking up the nuts one by one with a hammer, although in a few places machines have been introduced for this purpose. The kernels are usually exported as such, no attempt being made by the natives to prepare palm-kernel oil for export. The latter is somewhat like cocoanut oil in properties, and is principally used for the manufacture of soap in Europe. Dr. Preuss also gives some interesting information regarding two local varieties of this tree, which have been named the small and large fruited Liscombe respectively, and which both differ from the ordinary oil-palm in having more brittle shells inclosing their kernels, a peculiarity of obvious advantage to the kernel extractor. The following table shows the oil and kernel content, and other facts of commercial importance with regard to these varieties:

Variety.	Pulp in whole fruit.	Palm Oil in whole fruit	Palm Oilcontained inpulp.	Kernel in whole fruit.	Palm-kernel Oil in whole fruit.	Oilcontained in kernel.
	P.c.	P.c.	P.c.	P.c.	P.c.	P.c.
Small-fruited Liscombe........	71.0	32.6	45.9	9.54	4.9	49.2
Large ditto, ripe....	71.0	44.4	62.5	12.5	6.15	50.1
Ditto, ditto, unripe	64.5	40.8	62.4	17.2	8.5	50.1
Ordinary Palm.....	37.5	22.6	60.2	14.5	7.13	49.1

An examination of these figures will show that the fruits of both Liscombe varieties are richer in palm oil than that of the ordinary palm, although they furnish a smaller proportion of kernel. Since, however, the latter is less valuable than palm oil, this is no disadvantage. Of the two Liscombe varieties, it would be best to utilize the large-fruited kind, since this gives both more oil and more kernel than the small-fruited sort. The author calculates that at present rates the value of the products obtained from 100 kilos (225 pounds) of the Liscombe fruits would be 21s. 9d., while the corresponding value of the same weight of ordinary palm fruits would be 14s. 6d. A series of tables showing the probable profits derivable from this industry is given, but it is pointed out that the outlay of capital by Europeans in this direction would be unwise until machinery for the extraction of the palm oil has been devised, and, as far as the Cameroons are concerned, until a railway and good roads have been provided, so that the regular transport of fruits to the factories could be insured.—Oils, Colours and Drysalteries.

TRADE NOTES AND RECIPES.

Soldering with Nascent Borax.—In hard soldering with borax, direct, there are several little difficulties encountered that make the process somewhat difficult. In the first place the salt forms great bubbles in contact with the soldering iron, and easily scales away from the surface of the parts to be soldered. Besides this, the parts must be carefully cleaned each time prior to applying the salt. All these difficulties vanish if instead of borax we use its component parts, boric acid and sodium carbonate. The heat of the soldering iron acting on these causes them to combine in such a way as to produce an excellent flux, free from the difficulties mentioned.—Drug. Circ. and Chem. Gaz.

Liquid Driers.—Liquid siccatives, those driers without which no painter or varnisher can work, are used, as is well known, as an admixture to accelerate the drying of varnishes and paints. Very excellent products of this kind are in the market, but much inferior stuff is also offered for sale. They are placed on the market under the most varying names and claims, but the differences generally consist only in color and consistency, properties which are determined by the fluctuating quantity of turpentine oil added. Many driers, otherwise all right, possess the drawback that they form a heavy deposit, although clear and thin in the beginning, and that after some time separations and inspissation take place.

This is caused by the mode of production of the liquid drying agents and their application. In the first place, supersaturation frequently occurs, which gives rise to a heavy sediment. In the second place insufficient boiling is responsible, whereby the liquid siccative thickens and separations result. The production of liquid driers is quite simple, but must be conducted with the greatest care and accuracy. For this reason the manufacture is always tedious. Many varnish makers, therefore, look around for the so-called siccative preparations, which are said to possess all sorts of qualities, but do not offer the same difficulties in their preparation. Such a preparation was once offered to me—linoleate of lead. It was claimed that no sediment would form. Upon solution in oil of turpentine, I found in the residue—which was by no means slight—litharge in the natural form. Where was the drying power to come from, as this substance was only suspended and not even affected by the heat employed?

Another resinate was recommended to me as being of specially strong action. It was a dark preparation, prepared with manganese or other manganese compound, and might also have contained lead. The substance made a turbid liquid with oil of turpentine, which clarified only after a fortnight, and exhibited a heavy deposit composed of linseed oil or linseed oil and resin, with the addition of a certain quantity of various drying agents, which enter into solution in the linseed oil and combine intimately with the acids of the oil and the resin. The driers most employed are the oxides of lead and manganese and their salts. The strength of the drying agents varies considerably; the driers which readily combine with the oil or the oil and the molten resin have a stronger action than those which do not unite so easily.

The main point in the preparation of a siccative is a good boiling of the drying agent employed, since otherwise, if this is not accomplished, the liquid siccatives will thicken after protracted or little storing, or separations occur in the storing receptacles. In my practice I use for drying agents especially lead oxide, lead oxide calcined and manganese carbonate. These driers are boiled until a drop of the liquid mass placed on a glass or porcelain plate will, in the case of a resin and linseed oil mixture, crack off entirely upon pressure with the finger-nail, or in case only linseed oil was used, the mass can be drawn out into long threads from the spatula when the latter is taken out.

Following are some recipes of siccatives which have been tried for years and found excellent:

1. Heat 6 parts of linseed oil, well matured, and add to the same 1-125 part of litharge (lead oxide) and 0.375 part of sugar of lead (lead acetate), calcined, and boil until the mass draws long threads in the aforementioned manner. Now dilute with 10 parts of oil of turpentine, or if a still thinner consistency is desired, with a correspondingly larger quantity.

2. Heat 6 parts of matured linseed oil with 0.300 part of manganese carbonate until the mass also draws long threads, which generally takes place at 280 degrees C.; then dilute with 12 parts of oil of turpentine, or, if desired, the addition of the turpentine oil may be increased.

3. Moderately heat 2 parts of American resin and 6 parts of clear linseed oil until the resin is dissolved; next add 0.750 part of litharge and 0.200 part of lead acetate, calcined. Now place on the fire and cause to rise, whereupon add 0.200 part of manganese carbonate and boil, with rising, until a drop cracks off from the glass plate in the described manner. Thin with 8 parts of oil of turpentine.

4. Heat 3 parts of American resin and 3.5 parts of linseed oil (matured) until the solution of the gum is accomplished. Now add 1.1 part of litharge and 0.3 part of lead acetate, allow to rise on the fire, then add 0.050 part of manganese carbonate and boil until the hard drop will detach itself from the glass plate.

5. Heat two parts of American resin and 3 parts of matured linseed oil until the gum is dissolved. Then add 0.750 part of litharge and 0.200 part of lead acetate, allow to rise, next add 0.100 part of manganese carbonate and boil until the drop cracks off.

The production of siccatives by means of manganese is, in my opinion, decreasing more and more. In the first place these driers generally turn out very dark, almost black; in the second place the disadvantage of causing separations, after some time, in varnishes produced with lime resinate or to thicken if ground with paint.

In conclusion, a recipe for siccative powder may be of interest. Intimately mix three parts of lithopone, 3 parts of zinc white and 4 parts of manganese borate, and strain through a fine sieve. This powder is preferably added to white paints to accelerate the drying. —Farben Zeitung.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

New Cotton Exchange at Bremen.—Two things occurred in Bremen during the year just ended that were of interest to our people engaged in growing and selling cotton. One was the opening of the Bremen Cotton Exchange and the other the publication of a book entitled Die Baumwolle (Cotton).

Next to Liverpool, Bremen is to-day the leading cotton market for this continent. Before the organization of the cotton exchange in 1872, the German merchants had been getting their product chiefly from Havre and Liverpool, very little being imported direct. To become independent of British ports, it was necessary to get the patronage of the inland spinners. This proved no easy task. Not until a decade had passed did the Bremen exchange cease to be a local institution and acquire a standing of national importance; but ever since the development has been phenomenal. While the importation of cotton in the year 1870 amounted to only 157,689 bales, it ran up to 397,998 bales in the year 1880. Ten years later there were 812,538 bales and the year 1900 showed the enormous figure of 1,567,045 bales.

In showing the growth of these importations, the following table will prove of interest:

Year.	Bales.
1891	872,856
1892	803,405
1893	862,964
1894	1,025,221
1895	1,112,434
1896	1,123,206
1897	1,402,048
1898	1,765,353
1899	1,382,179
1900	1,567,045
1901	1,603,480
1902	1,726,435

A proportion of this cotton is being continually classified and arbitrated on. The following figures are officially reported for the past four years:

Amount of Cotton Arbitrated Upon.

	American. Bales.	Indian. Bales.	Total. Bales.
1899	1,274,697	156,653	1,431,350
1900	1,145,022	82,912	1,227,934
1901	1,251,945	189,536	1,441,481
1902	1,107,441	187,995	1,295,441

The next table shows that fully two-thirds of the American cotton is arbitrated on upon its arrival here, before it passes into the hands of buyers:

	Imported. Bales.	Arbitrated. Bales.
1899	1,366,899	1,274,697
1900	1,603,880	1,145,022
1901	1,579,527	1,251,945
1902	1,704,886	1,107,441

The new cotton exchange is said to be not only the most imposing structure of this nature in the world, but also the most complete in the appointments necessary for carrying on the business of buying and selling cotton and supplying the leading merchants and brokers with office and sample rooms.

To celebrate its opening, the members of the exchange published a handsome volume (745 pages) entitled Die Baumwolle, which is probably the most complete work on the subject of cotton. It was compiled by Prof. Oppel, of Bremen, who devoted years of the most careful study to this subject, extending his researches to every cotton-producing country.—Henry W. Diederich, Consul at Bremen.

Proposed Currency Changes in the Straits Settlements.—The burning question of the hour in this and neighboring districts is undoubtedly that relating to the currency.

As soon as it became known here that a commission had been appointed in England with a view to fixing a stable currency for Singapore and the Straits Settlements, on lines somewhat similar to that which changed the Indian monetary standard a few years ago, the press took up the subject. Siam, which had apparently been making preparations for the event for some time past, immediately closed her mints to the coinage of silver. In Singapore, Penang, and the Federated Malay States, the principal public bodies have held meetings to discuss the matter, and with one exception (that of the Chinese tin miners and mine owners, who are, however, an important and influential body) the general consensus of opinion has been for a fixed standard. This means either a dollar or rupee on a sterling exchange basis. It has been suggested by many influential business men here that this coin should be fixed at 1s. 8d. (40 cents). At the time of writing, when the Mexican dollar is at its lowest ebb, the bank rate of exchange is fluctuating in the neighborhood of 1s. 7d. (38 cents).

The currency of Japan, British India, Burma, Ceylon, Java, and Siam has been placed on a gold basis, and proposals for the same are under consideration in French Indo-China and the Philippines.

It will probably only be a question of a few months before the change is made here. The principal shipping firms have already fixed the scale of wages of their officers and engineers upon a sterling basis, while several of the more important houses in other lines of business are contemplating the same procedure.—Thomas Davidson, Vice and Deputy Consul-General at Singapore.

Architectural Contest in Greece.—The following has been received from Consul F. W. Jackson, of Patras:

Owing to the many inquiries which have reached me concerning the church architectural contest, referred to in my report of August 11, 1902,† to which it has been found impossible to give separate answers, I give herewith a few suggestions which may be taken into consideration in preparing plans for the contest of the second degree, if received too late for those of the first degree.

1. The proposed edifice will be constructed largely of cut stone. Extensive deposits of building stone are found across the gulf from Patras, two to three hours' distant by sailing vessel. Expert stone-cutters are to be had from the immediate vicinity.

2. Large quantities of marble will be employed in construction. The amount of marble to be used is variously estimated, and may be expected to exceed $40,000 in all.

3. All estimates should be based upon the supposition that walls are to be elaborately frescoed.

4. The general cost of unskilled labor should be reckoned at 40 to 50 cents per day. No estimates can be made for skilled labor.

5. The contest for the first degree closes at noon of February 13 (January 31, Greek calendar), 1903. Contestants in doubt as to the proper address may send their plans in care of this consulate, labeling them "Architectural contest."

To all inquirers, I have at once mailed circulars which should enable our architects to work on an equal footing with all others, and, if the plans are sufficiently Byzantine in general effect, their chances of success should be considered as good as those of England, Germany, or France.

† Advance Sheets No. 1441; (September 11, 1902).

German Chamber of Commerce for Tsintau.—Commercial Agent E. L. Harris reports from Eibenstock, January 3, 1903:

According to the Deutsche Kolonialzeitung, ten of the most prominent companies in the German colony of Kyao-chau, China, have organized and founded a chamber of commerce in the city of Tsintau. This makes the second enterprise of this nature undertaken by German merchants residing in foreign countries. The first one was established in Brussels a few years ago, and is doing good work for German commercial interests in Belgium. It is extremely probable that a third chamber of commerce will be founded in Bucharest by German merchants residing in Roumania.

Currency Changes in Siam.—Vice-Consul-General J. P. Selden reports from Bangkok, December 6, 1902, that Siam has closed the mint at Bangkok to the free coinage of silver, and has taken the initial steps to place herself upon a gold basis. Mr. Selden adds:

The tical, the standard coin of the realm, has up to this time had a fixed ratio value to the Mexican dollar of 60 to 100. The steady fall in the value of silver during the last six months has therefore greatly diminished the value of the tical, until during the latter part of the month of November, 1902, £1 was equal to 21 ticals and a fraction.

On November 27, 1902, a notice appeared in the several local papers that the royal mint would no longer issue ticals to the public in exchange for gold, silver, or copper, whether presented in the shape of bullion or coins. At the same time, the ratio of 17 ticals to £1 was fixed as the rate at which the Siamese minister in London would issue demand drafts on Bangkok against pounds sterling in London. This change paralyzed the business interests for the time, as the banks were liable for large amounts.

Under date of December 12, Mr. Selden reports that an arrangement has been made whereby the banks will sell drafts on London at 20 ticals per £1 and buy at 19.25 ticals per £1.

Tender for Rails in Siam.—The Royal Siamese Railway Department has just issued specifications for an open tender on 33,806 tons of steel rails and accessories. These supplies are for the railway which is to extend from Lopburi, the present terminus of the branch line of the Korat Railway, to Chiengmai, a city in the northern part of the country. The time limit for bids on the tender is six months—*i. e.*, from December 15, 1902, to June 15, 1903. All bids must be in on the last-named date. The sealed bids are for the first time to be opened in public.

I forward a set of specifications, conditions, and blue prints to the Philadelphia Commercial Museum. I inclose a notice of the tender, which appeared in the local papers last evening.—Joseph P. Selden, Vice-Consul-General at Bangkok.

Royal Siamese State Railways.

Tenders are requested for the supply of the following permanent way materials:

	Tons.*
Rails	30,000
Dog spikes	950
Fish plates	1,826
Bearing plates	750
Bolts and nuts	270
Spring washers	10
Total	33,806

Drawings and conditions may be obtained, against payment of 5 ticals (about $1.25), at the office of the Royal Railway Department. Sealed tenders, with the inscription "Tender for the supply of permanent way materials," must be forwarded before the 15th of June, 1903, at 10 A. M.

* 1 Ton = 2,205 pounds.

INDEX TO ADVANCE SHEETS OF CONSULAR REPORTS.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

SELECTED FORMULÆ.

Carnation Pink Perfume.—

Oil of cloves	5 minims.
Essence of cassie	4 ounces.
Essences of jasmine	2 ounces.
Essence of orange flowers	4 ounces.
Essence of rose	8 ounces.
Tincture of vanilla	2 ounces.
Tincture of storax	1 ounce.

—Drug. Circ. and Chem. Gaz.

Cement for Marble.—The Badische Landes Zeitung says that an excellent cement for broken marble consists of 4 parts of gypsum and 1 part of finely powdered gum arabic. Mix intimately, then with a cold solution of borax make into a mortar-like mass. Smear on each face of the parts to be joined, and fasten the bits of marble together. In the course of a few days the cement becomes very hard and holds very tightly. To get the best results the object mended with the cement should be left absolutely quiet for several days, not touching or moving it. In mending colored marbles the cement may be given the hue of the marble by adding the color to the borax solution.—Drug. Circ. and Chem. Gaz.

Harness Polish.—

Mutton suet	2 ounces.
Beeswax	6 ounces.
Sugar	6 ounces.
Soft soap	2 ounces.
Lampblack	1 ounce.
Spirit of turpentine	4 ounces.
Water	4 ounces.

—Drug. Circ. and Chem. Gaz.

Stencil Ink.—

Shellac	2 ounces.
Borax	1½ ounces.
Water	10 ounces.

Boil until the shellac is dissolved and add

Prussian blue	1 ounce.
China clay	1½ ounces.
Powdered gum arabic	1½ ounces.

—Drug. Circ. and Chem. Gaz.

Ink for Rubber Stamps.—The vehicle used in the preparation of inks for rubber stamps is gylcerin, a non-drying substance; so that pads charged with the color may remain usable indefinitely. Such ink, of course, is not as desirable as one that would thoroughly dry on exposure, but the latter—regular printing ink—requires a kind of handling too troublesome for most users of stamps.

Anilin colors are usually employed as the tinting agents.

The following is a typical formula, the product being a black ink:

Nigrosin	3 parts.
Water	15 parts.
Alcohol	15 parts.
Glycerin	70 parts.

Dissolve the nigrosin in the alcohol, add the glycerin previously mixed with the water, and rub well together.

Nigrosin is a term applied to several compounds of the same series which differ in solubility. In the place of these compounds it is probable that a mixture would answer to produce black as suggested by Hans Wilder for making writing ink. His formula for the mixture is:

Methyl violet	3 parts.
Bengal green	5 parts.
Bismarck green	4 parts.

A quantity of this mixture should be taken equivalent to the amount of nigrosin directed.

These colors are freely soluble in water, and yield a deep greenish-black solution.

We have found the anilin compound known as brilliant green to answer in place of Bengal green.

As to the permanency of color of this or any anilin ink, no guarantee is offered. There are comparatively few coloring substances that can be considered permanent even in a qualified sense. Among these, charcoal takes a foremost place. Lampblack remains indefinitely unaltered. This, ground very finely with glycerin, would yield an ink which would perhaps prove serviceable in stamping; but it would be liable to rub off to a greater extent than soluble colors which penetrate the paper more or less. Perhaps castor oil would prove a better vehicle for insoluble coloring matters.

Almost any anilin color may be substituted for nigrosin in the foregoing formula, and blue, green, red, purple, and other inks obtained.

Insoluble pigments might also be made to answer as suggested for lampblack.—Drug. Circ. and Chem. Gaz.

Glove Cleaners.—The following formulas for glove cleaning preparations are taken from the Druggists Circular and Chemical Gazette:

I.

Soft soap	1 ounce.
Water	4 ounces.
Oil of lemon	½ drachm.

Precipitated chalk, a sufficient quantity.

Dissolve the soap in the water, add the oil and make into a stiff paste with a sufficient quantity of chalk.

II.

White hard soap	1 part.
Talcum	1 part
Water	4 parts.

Shave the soap into ribbons, dissolve in the water by the aid of heat, and incorporate the talcum.

III.

White bole	600 parts.
Orris root	300 parts.
Soap, dry	75 parts.
Borax	150 parts.
Ammonium chloride	25 parts.

Powder and mix thoroughly.

Dampen the gloves with a wet rag, dust on the powder and then rub it well in. When dry brush off the residual powder.

NEW USE FOR CARBORUNDUM.

The Electrical Review (London) says that a new and valuable use has been discovered for carborundum, which is manufactured at Niagara Falls by the Acheson process, and that is covering firebrick with a highly refractory coating. Since carborundum can only be melted at extremely high temperatures, the electric furnace being required for the purpose, it follows that the temperatures ordinarily generated for smelting of ores and metals are much below its fusing point. Finely powdered carborundum is made up into a paste with water-glass, i. e., sodium silicate, or some similar binding substance; and the paste is applied by means of a brush, or otherwise, to the bricks which are intended to be used for building a furnace, or those bricks are actually immersed in the viscid liquid for a certain time. If the furnace has already been built, the paste can be painted on to the exposed surfaces, giving one or more coats as may be desired. It is stated that a layer 1-12 inch thick will protect the bricks from the attack of the highest temperature which is ever produced by combustion methods in ordinary work; examination of the bricks in such a furnace (after it had been pulled down) having shown that they had not suffered in the least. The skin of carborundum does not chip off, and is hard enough to resist mechanical injury.

CANADA'S OIL FIELD.

News comes from Quebec that oil has been struck in Raleigh Township, ten miles from Chatham, Ontario. The owners of the well are unable to say exactly what their yield is, there being only two tanks capable of holding 250 barrels each. As the oil has to be carted away, the tanks cannot be emptied quickly enough to permit the gushers being constantly worked. According to the New York Sun permission to pipe the township has been obtained, and both the Michigan Central and the Lake Erie and Detroit railways are building sidings to the well. Other borings are to be made at once, and, though it is realized that the openings of the other wel'l will somewhat reduce the output of the present one, its owners say that a gusher which has started as thir on- has is bound to last for some time.

It is very apparent that whether the output of the new fields be large or small, the Standard Oil Company has secured the bulk of it, and already shipments have been made to the Imperial Oil Company of Sarnia, which is a branch of the Standard Oil Company. The latter company has also secured leases on the balance of the land in the district owned by the Canada company, as well as upon other territory.

The Canada company originally owned the land upon which the new well is located, as well as most of the surrounding farms, and litigation will undoubtedly follow the recent discovery. Instead of purchasing their rights from the farmers on whose lands they bored, the prospectors bought them from the Canada company, to whom the lands were granted by an old act of George IV. In the original charter there was no right reserved to the minerals, but when the Bothwell oil boom started in 1864, the company secured the passage of a special act of the Dominion, authorizing them in future leases to reserve the mineral rights. Most of the farmers were unaware of this act, and up to the present thought that they owned the minerals in their land. On the other hand, the farmers believe that the act only refers to leases of lands and not to sales, and, since many of them have deeds of their property, some heavy lawsuits are certain. In spite of the assertions of the Canada company, many of the farmers have granted leases to prospectors and will let the latter fight it out with the company.

THE TONGE HYDRAULIC MINING CARTRIDGE.

The Journal of the Society of Arts gives particulars of the Tonge hydraulic mining cartridge, to which the Council of the society awarded the Benjamin Shaw prize. This cartridge is intended to replace explosives in fiery mines, and is simply an ingenious modification of the ordinary hydraulic press. It consists of a steel cylinder 20 inches long by 3 inches in diameter, along one diameter of which are arranged a series of eight small rams, which are telescopic, so that the available traverse is practically doubled. In using the device, after the coal has been undercut in the usual way a 3¼-inch hole is drilled along the roof line into the coal for a depth of 3 or 4 feet. The cartridge is then pushed into the hole, backed by one or more liners, as may be necessary, under the line of the rams. Water is then forced by hand pumps into the cartridge, and forces out the rams, a pressure of 3 tons per square inch being readily attainable. In about 10 minutes the coal is brought down by the action of the rams, and is obtained in large pieces, the dust and small coal being much less than is the case when explosives are used. In practice, it is stated that one man can make 25 to 30 "thrusts" per shift, or about 150 per week, which will yield about 300 tons of coal, of which 75 per cent will be large coal. The actual weekly cost of working is practically the same as with ordinary explosives, but the value of the coal obtained is much greater. The apparatus has been in use for two years in different mines. In one of these 19,000 "shots" or "thrusts" have been made by four machines in 12 months, which yielded 40,000 tons of coal. The seam at this mine is made up of 3 feet good coal underlaid by 4 inches of dirt, and another 2 inches of coal. The undercutting is done in part by machine, the depth of cut being 5 feet 9 inches. The cartridge holes are then drilled to a depth of 5 feet, and are spaced 6 feet apart. Where hand holing is used the depth of undercut is 4 feet, and the cartridge holes are made 3 feet 6 inches deep and spaced 7-foot centers. Four men look after the four cartridge machines, one of which is always kept in reserve. These men go round the workings and break down the coal for each miner as soon as the latter has finished his undercutting and drilled his cartridge hole. The use of explosives has been entirely superseded by the machine in these mines.

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